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THE THEORY AND CONSTRUCTION OF FORTIFICATION.

Illuſtrated with ſeveral New Deſigns.

By Lieutenant **CHARLES BISSET**,

K

Late an Engineer Extraordinary in the Brigade of Engineers which ſerved in the Netherlands in the laſt War.

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MVSEVM
BRITAN
NICVM

TO HIS ROYAL HIGHNESS THE DUKE,

Captain-General and Commander in
Chief of all His Majeſty's Forces,
&c. &c. &c.

SIR,

THE following Treatiſe being an Attempt to advance towards Perfection an eſſential Branch of the Military Science, I humbly beg Leave to place it at your Royal Highneſs's Feet.

The great Regard your Royal Highneſs has always ſhewn to every Improvement of Martial Knowledge; and the Countenance with which you were pleaſed to reward my Services under your Command, have given me Preſumption to hope, that this Product of Experience gained by the Honour of attending you, will not be altogether rejected.

The Hopes of ſo illuſtrious a Patronage has indeed encouraged me to a very laborious Proſecution of my Deſign; nor can I permit myſelf to deſpair of obtaining it, ſince Magnanimity and Candour are ever inſeparable. The World knows how eminently your Royal Highneſs excels in the firſt of theſe Qualities, which you have gloriouſly exerted in Defence of the Liberties of your Country and of Mankind, and the gentle Influence of the other is moſt ſenſibly felt by all thoſe who have the Honour of approaching you; among whom may your Royal Highneſs be pleaſed to admit,

SIR,

Your Royal Highneſs's

moſt devoted,

moſt obedient, and

moſt humble Servant,

April 15.
1751.

Charles Biſſet.

THE

PREFACE.

IT is Matter of no ſmall Surprize, that the beſt Treatiſes extant of the Theory and Conſtruction of Regular Fortification are ſtill ſo vague and imperfect, and that the lateſt Productions of this Kind ſhould be the moſt ſuperficial; nor is it leſs amazing, that the Art of fortifying equally irregular Circumferences has been almoſt wholly overlooked by every Writer on Fortification that has hitherto appeared.

The Chevalier de Clairac, an experienced and judicious Engineer, who, in 1749, publiſhed a Treatiſe of Temporary or Tranſient Fortification, comprehending chiefly Lines, Retrenchments, and Redouts for the Defence of Armies in the Field, affirms, "That there are ſcarce four "Books of Fortification that are worthy to be read, nor "any one that contains much real and uſeful Knowledge. "The Conſtruction of Fortification, continues this Author, "embraces ſo many different Objects, and depends on ſo "great a Variety of Circumſtances, that few Authors have "given any tolerable Account of it."

Marſhal de Vauban has given us a full and excellent Treatiſe of the Attack, a few Errors excepted, which indeed would ſeem principally to have been interpolated, ſince we that ſome of them which relate to the Conſtruction, do not exiſt in Mr. Vauban's beſt and compleateſt Deſigns that are actually executed, whereof one remarkable Inſtance happens to come in our Way, in the Courſe of the enſuing Work (Par. 125. 202.): This Treatiſe of the Attack was publiſhed ſome Years ago in Holland; and Mr. Clairac informs us there is alſo a compleat and maſterly Treatiſe of the Defence, in Manuſcript, by the ſame Author, different from that which is annexed to his printed one of the Attack. But this great Engineer has unluckily left us nothing in Detail of the Theory and Conſtruction of regular and irregular defenſive * Enceintes.

Baron Coehorn publiſhed, when young and unexperienced, three new Methods of Fortification, with minute Details of their Defences; which diſcovered a copious Invention, uncommon Penetration, and a promiſing military Genius: But as he neither ſuppoſes the Uſe of † Ricochet Firing,

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* By Enceinte, in Fortification, is generally meant a fortified Circumference, or Incloſure. In this Senſe it is always us'd in the following Treatiſe.

† A Method of firing with Cannon and Hobit, firſt practiſed by Marſhal Vauban; which conſiſts in giving the great Gun, or Hobitz, an Elevation of about twelve Degrees, and loading it with a ſmall Quantity of Powder, ſo as to make the Bullet, or Shell, juſt graze over the Creſt of the Parapet, and plunge into the Work againſt which it is determined: The Bullet, as ſoon as it lights, provided the Angle of Incidence is very ſmall, is reflected at the ſame Angle, and bounding along the Ramparts, by frequent Impulſes and Reflections diſmounts the Cannon, drives the Beſieged from the Defences, and in the Baſtion takes the oppoſite Flank in Reverſe; it likewiſe deſtroys the Paliſadoes of the covered Way, and thoſe of Retrenchments. To play the Ricochet with Succeſs demands all the Attention and Dexterity of the ableſt Gunners. At Bergenopzoome, where it was played by the French with the utmoſt Care, and doubtleſs

Firing, which was not then diſcovered, nor Bombs to be thrown into the Works attacked, in that Profuſion they have been of late Years, and had little or no Experience before he publiſhed his Methods; the Maxims therefore which he has eſtabliſhed, and the Principles on which he founded his Syſtems, are, in many Reſpects, unjuſt. Neither has this excellent Engineer left us any particular Account of the Theory and Conſtruction of Irregular Fortification.

Some Treatiſes of Fortification have been publiſhed within theſe few Years, which are apparently the Productions of Perſons of very little or no Experience, ſince they lay down Maxims, and aſſert Facts, in Fortification, that have no Foundation in Practice: Therefore the Syſtems they build on ſuch Hypotheſes muſt neceſſarily be erroneous: Indeed, they never attempt to enter into the Spirit of the Science, but reaſon much about Things of trivial Moment, while they neglect the more eſſential Parts: They ſeldom fail to tranſcribe the Errors of preceding Authors, and often blame Authors of Experience, becauſe they are either ignorant, or have no diſtinct Idea of their juſt practical Motives:

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doubtleſs by their beſt Gunners, the Bullets flew generally too high, and went clear over the Baſtion: Thoſe ſent from the great ricochet Battery in the Field oppoſite to the Baſtion King William, which were determined againſt the Baſtion Pucelle, and the Curtain to its right, generally lighted in the Curtain between the Baſtions Belvidere and Coehorn, and bounded along its Rampart, or in the Gorge of Belvidere; they frequently, however, grazed along the Tops of the Breaſtworks, and took the right Flank of Pucelle, or the Screen that covered it, in Reverſe; ſometimes they were too low, and were loſt againſt the Face of the Rampart; and when they lighted in the Baſtion immediately within, or at a ſmall Diſtance from the Breaſtwork againſt which they were directed, they ſeldom were reflected, or went any farther, their Elevation being, in that Caſe, too great, and the Quantity of Powder too ſmall. So that it is ſcarce poſſible to enfilade the Platform of the Face of a high Baſtion by the Ricochet; the Bullet may, nevertheleſs, do Execution therein before it lights on the Ground, but the covered Way and Outworks may be ſcoured thereby with more Succeſs.

Beſides, they overlook many things of Conſequence that are tranſiently mentioned by theſe Engineers, and which appear readily in their true Light to Engineers of Experience only.

This general Hint which I give of the Errors of theſe late Authors, proceeds from no other Motive than a Love of Truth; nor can it be regarded as any Reflection on their Capacities or Judgments, ſince thoſe Imperfections naturally flow from Unexperience in the Practice of the Art: Their Deſign is nevertheleſs praiſeworthy, and their Works, in many other Particulars, ingenious, juſt, and uſeful.

As the Theory, Rules, and Maxims of Fortification given us by former Authors are ſtill very imperfect; and as the Defence is the ſole Object of the Conſtruction of defenſive Works, ſo no Perſon unexperienced in the Practice of this Art, can, at preſent, ever hope to ſucceed well in projecting new Syſtems of Fortification, or in fortifying irregular Circumferences. Tho' I have not the Abilities and all the Experience neceſſary to execute a Treatiſe of Fortification that ſhall be entitled to any high Degree of Merit, yet the Length, and great Variety of the late Siege of Bergenopzoome, has furniſhed me with Ideas ſufficient, as I imagine, to exhibit the Doctrines both of Regular and Irregular Fortification, in a more practical, and extenſive, and perhaps juſter Manner, with regard to the Conſtruction, or Deſign, than any thing of this Kind that has yet appeared; for the Journals of the Attack and Defence of Bergenopzoome, which I had the Honour of writing by his Royal Highneſs the Duke's Orders, required my giving the moſt diligent Attention to the Manner of conducting the Defence, and to the Progreſs and Effects of the Attack; and thoſe Engineers, whoſe high Abilities and great Experience enabled them to produce juſter and more maſterly Performances in Fortification than I can pretend to, have had no Leiſure, and perhaps leſs Inclination to ſubmit to the Labour of collecting and properly ranging their Ideas of all the different Acts and Efforts of the Attack and Defence, and their true Effects, and deducing from theſe neceſſary Conſequences upon which to eſtabliſh juſt Maxims, and Rules, and Conſtructions of Fortification, ſince they have been generally occupied in the Attack or Defence in time of War, and in fortifying Frontier Towns during Peace.

I do not flatter myſelf, that the following Treatiſe of Fortification is without Errors, or that they will eſcape the Obſervation of others; on the contrary, I ſhall think myſelf obliged to any one who will take the Trouble to diſcover and correct them ; nor ſhall I bluſh to relinquiſh them as ſoon as they are pointed out ; for, as Imperfection is inſeparable from human Nature, nothing is more ridiculous than to ſee an Author perſiſt, in an erroneous Practice, and adhere to groundleſs Opinions, becauſe he has once been unlucky enough to write in favour of them. I have been careful, however, never to deviate from practical Facts for the ſake of any favourite Hypotheſis ; for my Aim has been, by a cloſe Inveſtigation of Truths, to diſcover, and exhibit, in a clear and regular Manner, the various Principles of Regular and Irregular Fortification ; and from thence to correct many wrong Notions relative to theſe Branches of Engineering which now generally prevail : And this without the leaſt Prejudice in favour of any particular Syſtems or Opinions of my own, or againſt any of thoſe of other Authors. Upon the whole, tho' this Work has not all the Accuracy and Perfection that is requiſite, yet I humbly preſume the Science may, in ſome meaſure, be thereby improved; and that it will incite ſome other Engineer, properly qualified, to exert his Talents in obliging the World with an almoſt perfect Work of this Kind. Before I conclude, I cannot help acknowledging, with a juſt Senſe of Gratitude, the Obligations Colonel Napier and Lieutenant-Colonel Scott have laid me under, for the Encouragement and Opportunities I have had, by their good Offices, to purſue the Study of this Science, and of acquiring Experience in the Practice of it; and for ſeveral judicious Remarks in Fortification theſe ingenious Gentlemen have been pleaſed to impart to me.

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ERRATA.

Page 2. l. 3. of the Preface, *ſince we that*, read *ſince we find that.*
6. of the Introduction, l. 21. *wherein*, read *whereon.*
Ditto l. 31. *heretofore*, read *hitherto.*
1. l. 4. of the Title, *Advatages*, read *Advantages.*
9. l. 29. *and the Sand Bags*, read *and Sand Bags.*
26. l. 3. *Lodgements*, read *Lodgement.*
27. l. 1. of the Note, *Lodgements*, read *Lodgement.*
35. l. 11. *ſhorter*, read *longer.*
43. l. 3. *Advantages*, read *Advantage.*
50. l. 8. *Diſadvantage*, read *Diſadvantages.*
52. l. 9. *ſimply*, read *ſimple.*
Ditto, l. 28. *ſingle*, read *ſimple.*
54. l. 25. *beore*, read *before.*
79. l. 9. *Conſtruction*, read *Conſtructions.*
132. l. 1. 55, read 155.
140. l. 4. *covered Way is, in Conſequence*, read *covered Way, in Conſequence.*
153. l. 13. *from the further Aggreſſors*, read *further from the Aggreſſors.*
160. l. 3. 156, read 151.

THE INTRODUCTION.

NOtwithſtanding the ſeveral Pieces of defenſive Incloſures are naturally ſuſceptible of infinite Diverſity in their Forms, Heights, and Magnitudes, their Diſpoſition with reſpect to one another, and in the Breadth and Depth of their Ditches; yet they have, in Fortification, their Modes, Dimenſions, and Arrangements determined, and reſtrained within certain Limits, by a Multiplicity of Circumſtances and Conſiderations which have the Defence for their Object, and conſtitute the Principles of the Art; and theſe are attained by Experience, and depend intirely on a thorough Knowledge of all the Variety of the Attack and Defence of fortified Places, the real Effects produced by the Efforts on either Side, and the Properties of defenſive Works that are thence deduced. Theſe Principles of Fortification muſt then neceſſarily be many and various; and they are ſtill, in ſome meaſure, diverſified, according to the Diameter of the Circumference required to be fortified, and the Sum allowed for executing the Deſign. But as the Method of Flanking is always ſimple, invariable, and in every Syſtem, and every Circumference the ſame; and as we muſt always, in whatſoever Manner we diverſify thoſe Modes of defenſive Works, principally regard the juſt Method of Flanking, ſo this Circumſtance, in particular, contributes greatly to render the Science of Fortification leſs complex, with regard to the Conſtruction of Enceintes on horizontal Plains; which therefore may be proſecuted with leſs Difficulty, to a high Degree of Perfection.

When the Qualities above mentioned of defenſive Works, and their Diſpoſition with reſpect to one another, are, by a thorough Knowledge of the Principles upon which they depend, ſo determined as to form a regular and ſymmetrical Front of Fortification, that ſhall be the ſtrongeſt that can be raiſed at the Sum that is neceſſary to the Execution of it, ſuch a Front, or Method of Fortification, is deemed regular and perfect. The great End that is then required, is to form ſeveral ſuch perfect defenſive Syſtems, at different Expences, and conſequently of different Degrees of Strength, each of them being the ſtrongeſt and moſt ſimple, in proportion to the Expence of its Conſtruction. This the ableſt Engineers have ever aimed at; and this I am of Opinion is yet far from being effected.

The Doctrine of Regular Fortification ſeems incapable of being demonſtrated geometrically, or by any Method that will amount to a mathematical Certainty; ſo various and undeterminate are the Principles upon which it depends: We can only inveſtigate the Properties, and moſt advantageous

Modes and Arrangements of defenſive Works, by a Chain of Reaſoning, founded on a true Knowledge of all the Principles above mentioned, that relate to the Conſtruction, being always careful to obſerve an inviolable Attachment to Practice. Therefore it is not to be expected, that any Deſigns of Fortification can be altogether perfect. But, as Regular Fortification admits not of very great Variety, provided we ſtrictly adhere to the Principles of the Science, it may poſſibly be within the Reach of the human Underſtanding, to project as many different, and truly methodical defenſive Syſtems, nearly, as the Science of Fortification is ſuſceptible of, within a certain and practicable Expence. We have already ſome good ones, and thoſe that are ſtill more perfect, and undiſcovered, may, by Degrees, thro' the Efforts of different Engineers, and in a few Years, be brought to Light; as well as ſome advantageous Particulars, in the Conſtruction, before unknown, which being judiciouſly added to the beſt Methods already invented, may contribute to render them ſtronger and more compleat, in proportion to their Expence. When this then is once accompliſhed, it will be no difficult Matter for ſome able Engineer, from theſe various Deſigns, to point out, and demonſtrate, as near as poſſible to Truth, the beſt Methods for Practice; which may remain ever after as Standards for general Uſe, or ſo long as no new invented and more powerful Artillery, or other Machines or Methods of Attack, oblige them to be altered. It is with a View then to contribute to this End, and to enlarge, in ſome Degree, the Knowledge of Fortification, that I give the ſubſequent Nine Regular Methods of Fortifying, whereof Four or Five may perhaps be allowed to have the Preference, in ſome material Reſpects, to any hitherto publiſhed; and were the firſt of theſe ſuperior even to Mr. Coehorn's of Bergenopzoome, I ſhould thence claim no particular Merit, it being eaſy to improve the Deſigns of the greateſt Geniuſes in Fortification, when ſuch Deſigns actually executed have been ſubmitted to the ſevere Teſt of a judicious Attack, for the Advantages and Diſadvantages attending them do naturally preſent themſelves in the Courſe of the Siege; and tho' theſe new Methods may be ſtill remote from the higheſt Point of Perfection, yet they may afford, at leaſt, ſome uſeful Hints to an Engineer of conſummate Judgment and Experience, towards conſtructing and determining the beſt Syſtems for Practice.

I have not drawn Compariſons of theſe Methods, and the moſt approved defenſive Syſtems of other Authors, becauſe the Work would have been thereby render'd too tedious, on account of the Multiplicity and Variety of the Circumſtances attending the ſeveral ſuppoſed Attacks and Defences of the Methods in Competition, ſince theſe muſt be minutely conſidered and compared before we can determine, with any high Degree of Certainty, the Quantity of Strength of each Method, and by Conſequence the Exceſs of it, in the ſtronger ones above the weaker; and alſo becauſe the Advantages and Improvements which are peculiar to our Methods of Fortification, may be readily diſcerned by the Reader, from an attentive View of their Plans, and of the ſeveral Particulars relating to their Defences, and the Principles on which they are founded, which are exhibited in the Courſe of the firſt and ſecond Sections of the enſuing Work, comparing them, at the ſame time, with the Conſtructions of preceding Authors.

INTRODUCTION.

The determinate Lengths of defenſive Fronts, which have the Aſcendant, in point of Strength, above all others, I have endeavoured to demonſtrate and aſcertain, from undubitable Facts in Practice, as well as many other Particulars that have hitherto remained undetermined, and that are not leſs eſſential not only to the well underſtanding of Regular but alſo of Irregular Fortification; whereby the Doctrine of the former, which has been heretofore ſet down, and generally underſtood in the moſt vague Manner, is eſtabliſhed on clear and certain Principles.

Irregular Fortification conſiſts in Fortifying, to the ſame degree of Strength, each of the ſeveral Sides of any irregular Polygon, in every different Situation that can poſſibly ariſe from the particular Figure of the Superficies, and the Quality of the ſubjacent and invironing Ground of ſuch irregular Polygon, in regard of Hills, Rocks, uneven Ground, Sea, Lakes, Rivers, Marſhes, and every other natural Cauſe that may be capable of increaſing or diminiſhing the Strength of any particular Front in the Enceinte more than another; Irregular Fortification will therefore admit of almoſt infinite Variety, which will render it incapable of being reduced under general Rules; neither is it poſſible to demonſtrate the degree of Strength of irregular Works and Fronts geometrically: There are nevertheleſs certain Principles, on which the Art of fortifying irregular Circumferences depends, in a very conſiderable Degree, which have not as yet been rightly explained, nor even ſcarce hinted at by any Author that I know; which Principles of Irregular Fortification I ſhall ſet to View in the cleareſt Light, in the enſuing Treatiſe; together with ſome Models of Fortreſſes adapted to certain irregular and important Situations, which moſt commonly occur in Practice, and are moſt difficult to be fortified, and that tend to clear up, and reduce to Science this complex and extenſive Branch of Engineering.

The circumſtantial Detail of the Defences of the Works of the principal Fronts of Bergenopzoome, which takes up the firſt Part of this Work, I have introduced previous to the Conſtructions of Regular Fortification, becauſe it will not only ſerve to diſplay the judicious Conſtruction and ſurpriſing Strength of thoſe maſterly defenſive Fronts which were deſigned by the celebrated Baron Coehorn, but will alſo give conſiderable Light into the Nature and Principles of Fortification in general, more eſpecially by means of the Trial which this Fortreſs ſuffered under the French Attack commanded by Marſhal Lowendal; in the Courſe whereof many Incidents occurred that gave Riſe to the Remarks and Obſervations which are interſperſed throughout the firſt Section of this Work; and becauſe theſe practical Remarks will be of Uſe to clear up ſome Points of the utmoſt Conſequence in Fortification, that have been hitherto undetermined, or of which falſe Notions have generally prevailed; and alſo to ſtand as Facts wherein I ſhall found the Conſtructions of certain Particulars of the ſubſequent Methods of Fortification. Beſides, the following Narrative of the Defences of the principal Fronts of Bergenopzoome, will lead the Reader to underſtand, in a great meaſure, the firſt of our Methods, and on what Principles it differs, and in what Reſpects, from the Method of Bergenopzoome, from whence it derives its Origin.

The modern Fortification had its Riſe on the Continent, and has there alſo acquired the ſeveral Improvements which have been heretofore at different Times made therein: For this Reaſon all the original Terms of the Art are foreign; there are ſome of theſe, chiefly French and Italian, which I may be allowed to make Uſe of in the Courſe of this Work, ſince they cannot be tranſlated into Engliſh without a Circumlocution; for we have no ſynonymous ones to expreſs the ſame things: Bulwark is indeed a proper Engliſh Term, ſignifying the ſame as Baſtion; but, as it has at preſent too general a Meaning, being applied indiſcriminately to any huge, ſtrong, defenſive Work, the Term Baſtion, I preſume, is preferable, notwithſtanding the former is more expreſſive, ſince it conveys ſome Idea of uncommon Strength, peculiar to the Work it ſtands for. There are alſo ſome foreign Terms that have, of late Years, become adopted, as it were, to our Language, and will be more univerſally underſtood, even by Engliſh Readers, than any Engliſh Terms I could have ſubſtituted in their Room. I have introduced, however, more Engliſh Terms of Fortification than has been done by any former Author.

I have been under a Neceſſity of making Uſe of the French Meaſures of Feet and Toiſes, preferably to the Engliſh ones, that the Dimenſions which we give to the outward Side, in different Conſtructions, and different Polygons, and to the ſeveral Members of defenſive Fronts, may be more eaſily compared with thoſe aſſigned them by the beſt French Engineers.

In this Work I have not purpoſely omited any material Circumſtance or Conſideration eſſentially neceſſary to the well underſtanding either of Regular or Irregular Fortification, and the Properties of defenſive Works, tho' I have deſignedly neglected to mention many trivial ones, ſince theſe naturally preſent themſelves to the Imagination of every attentive Reader. I have alſo numbered the Paragraphs, becauſe of the References which frequently occur in the Courſe of this Work, from the mutual Dependance and Relation which the ſeveral Parts of the Subject have to one another: By this Means tedious Recapitulations are, as much as poſſible, avoided, and the whole is thereby rendered more conciſe and diſtinct.

SECTION I.

Of BERGENOPZOOME.

CHAPTER I.

A general View of the Conſtruction of the Fronts, in the Enceinte of Bergenopzoome, *which were concerned in the Defence in the late Siege; with a Detail of the principal Advantages and Diſadvatages attending their ſeveral Works, deduced from a cloſe Obſervance of the Attack and Defence, during the Siege.*

Par. 1. GEneral Coehorn's Method of the ſeveral Fronts of the Fortification † of Bergenopzoome, included between the Baſtion to the right of Antwerp Port, and the Baſtion to the left of Wou Port, and the Lines of Halterin and Kykinpot, (PL. 1) approaches the neareſt, perhaps, of any hitherto invented, to that ultimate Degree of Perfection which is the principal Aim of every Method, or particular Arrangement of defenſive Works; and which conſiſts in Strength and Simplicity, in the higheſt

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† A Front of Fortification, or of an Enceinte or fortified Incloſure, comprehends two Demibaſtions, their intermediate Curtain, and all the anterior Outworks.

Point theſe are capable of being obtained together, at any determinate Expence.

2. The Outworks of this Method conſiſt of a Ravelin, (F) and two large † reveted Lunettes (I, K.) in the covered Way, in each Front: The Ramparts of theſe latter are low, their Ditches narrow and ſhallow, and the Expence of them conſequently ſmall; and the covered Way is untraverſed at the ſaliant Places of Arms; yet the Strength of theſe defenſive Fronts is very conſiderable; which was in ſome meaſure manifeſted in the late Siege, and is ſtill more ſo by the ſubſequent Computation. (25.)

3. Mr. Coehorn, having obſerved that the great Ditch and its Counterſcarp; the Outworks, their Ditches and Counterſcarps, and the Glacis, are flanked and commanded more powerfully, and with much greater Succeſs in a ſhort Front, then in a long one; on which depend chiefly the Length, Dicffiulty, and Fatality of the Attack; he has therefore given the exterior Sides of the Fronts abovementioned, (1) between 140 and 150 * Toiſes only; which conſequently poſſeſs in great Perfection, the important Advantages ariſing from the Proximity of the great Ditch and its Counterſcarp, the Outworks, their Ditches and Counterſcarps, and the Glacis, to the Fire of the Defences that command and bear againſt them; (39, 41.) and ſo as to overbalance greatly the Diſadvantages which do neceſſarily ariſe from the Shortneſs of the Fronts: (47.) But as he has very ingeniouſly evaded one of the principal Diſadvantages, by producing to a conſiderable Extent the Flank of the Baſtion, without lengthening, in any conſiderable Degree, the Perpendicular,

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† Reveted, or clothed with a Wall of Maſonry.

* A Toiſe is equal to ſix Royal French Feet, and the French Foot is to the Engliſh as 16 is to 15 nearly.

and conſequently without incurring any of the Inconveniencies which muſt have been induced thereby, (63.) ſo the Advantages, abovementioned, obtained by Means of his ſhort Fronts, will overbalance the Diſadvantages in a ſtill greater Meaſure.

4. The Flank of the Baſtion in the principal Fronts before mentioned, (1) this able Engineer has extended by producing the interior Extremity of the ſtraight Flank within the Direction of the Line of Defence, and by adding to the outward Extremity of the concave high Flank, a concave Breaſtwork which runs within the Gorge of the Orillon, and is terminated at the Face of the Baſtion, the Orillon being depreſſed below it. The interior additional Portion extends to the Length of about three Toiſes within the Line of Defence, (PL. I. N.) by which means a conſiderable Portion (M) is annexed to the high concave retired Flank, ſufficient to contain two Pieces of Cannon, which I ſhall term the Flank of the Gorge, to diſtinguiſh it from the true Flank, or that Portion of the Flank, from whence is ſeen the Foot of the Wall of the whole Face of the oppoſite Demibaſtion. This Flank of the Gorge has nearly all the Properties of the true Flank; and beſides, it bears more directly than the true one, againſt the Gorge of the Ravelin, and that of the oppoſite Lunette; and againſt the Counterſcarp before the Face of the oppoſite Demibaſtion; and is therefore at leaſt as uſeful: The pointed Lines (TS) exhibit the Space of the great Ditch and oppoſite Counterſcarp which falls without the Range or Line of Fire of its Cannon on the Side of the oppoſite Baſtion, which is trivial. The two Pieces of Cannon in the high Flank of the Gorge of the Baſtion King William bore, in a pretty direct manner,

againſt three of the four Cannon, (R) which battered in breach, on the firſt Day, the right Face of the Baſtion Pucelle. The two Pieces of Cannon, (T) in the right high Flank of the Gorge of the Baſtion Pucelle, bore againſt the Lodgement of the Enemy on the covered Way, before the left Face of the Baſtion Coehorn, and their Lodgement in the Drum (W) of the Lunette Zeland (K) with good Succeſs; and againſt the Battery (X) of the Enemy, which battered, in Breach, the left Face of the Baſtion Coehorn, but with leſs Succeſs, by reaſon of the Acuteneſs of the Angle of their Direction againſt that Battery. The Extremities of the ſtraight, middle Portion (P, N) of the Curtain produced, interſect the ſtraight Flanks in the ſame Points with the Lines of Defence; and the Retreat, or inflected Extremity (NM.) of the Curtain is directed to the vertex of the Angle of the Shoulder of the oppoſite Baſtion, or a little more outwards; ſo that the Flanks are lengthened, without adding, ſcarce any thing, to the Ditch of the Curtain; and without incurring any of the Diſadvantages which would ariſe by giving a greater Length to the Perpendicular, (47, 63.)

5. The high concave Flank of the Baſtion in theſe Fronts, (I) is ſtill enlarged, as we have ſaid above, by the Addition of another conſiderable Portion (Z) to its outward Extremity, where it is terminated by the Retreat of the Orillon, which is concave, and may, for Diſtinction Sake, be termed the high Flank of the Orillon. This Flank of the Orillon is alſo of good Uſe, and bears againſt the oppoſite Counterſcarp, and Creſt of the Glacis, before the Angle of the adjacent Baſtion; and againſt the Top of the Breach of the oppoſite Face of that Baſtion, and the Breach

of its Orillon ; and obliquely againſt the Ravelin ; the Orillon being conſtructed lower than the Terreplain of the Baſtion, chiefly to allow the ſaid Flank to fire over its Creſt : It alſo ſerves to cut off the Communication of the Orillon from the Baſtion ; for the Beſiegers might otherwiſe be tempted to direct their Attack chiefly againſt theſe Orillons, becauſe they are low, and liable to be breached in Front from the oppoſite Counterſcarp before the ſaliant Angle of the Ravelin : But this high Flank (z) of the Orillon is productive, I ſuſpect, of Diſadvantages that are greater than all the good Effects which it is capable of producing, (81.)

6. The Terreplain of the Orillon is ſeven or eight Feet lower than that of the Baſtion, that the Bottom of the Ditch of the Ravelin may be wholly and eaſily ſeen from the Breaſtwork of the Orillon ; alſo that the Enemy may not be able to batter it from the field ; and that it may allow the high Flank to fire over it : But the Guns which are planted thereon do, in Conſequence of its lowneſs, oppoſe with leſs Advantage the Battery of the Enemy on the Creſt of the oppoſite Glacis, before the ſaliant Angle of the Ravelin, and its Breaſtwork is more liable to be ruined by that Battery. In the late Siege of Bergenopzoome, ~~the~~ left Orillon (v) of the Baſtion Coehorn played with good Succeſs againſt the Lodgement of the Enemy, at the ſaliant Angle of the covered Way of the Ravelin ; and contributed greatly to retard and ruin that Lodgement. No Inconveniency can ariſe in this Conſtruction, from the Orillon's not covering the high Flanks of the Baſtion, becauſe they are ſufficiently covered from the Batteries of the Enemy in the Field, by the Ravelins and Lunettes ; and though they were leſs covered from the Field, yet that would be no material

Diſadvantage, (31, 32.) The Uſe of the Orillon then, in this Conſtruction, is to flank, as we have already obſerved, the Ditch and covered Way of the Ravelin, to cover the low flank from being enfiladed from the Field, or plunged into from the Counterſcarp; and to cover, in ſome meaſure, one of its Guns from the Enemy's counter Battery on the oppoſite Counterſcarp.

7. It is remarkable, that Mr. Coehorn has given ſquare Orillons, with vaulted Batteries which open at their ſquare Extremities to ſome of the Demibaſtions; which Method, however, of caſemated Orillons, he has, not without Reaſon, entertained ſome Diſtruſt of; for he has given round and ſolid ones to the Demibaſtions of the Fronts which muſt neceſſarily be attacked by the Aggreſſors, if they attack the Town without the Lines of Halteren and Kykinpot; and the ſquare Orillons, with their ſubterraneous Batteries, to Fronts of much leſs Conſequence, and which cannot be attacked, unleſs the Beſiegers are Maſters of either of theſe Lines; becauſe, I ſuppoſe, he found his vaulted Orillons were liable to be penetrated, and ruined, from the Creſt of the Glacis of the covered Way of the Ravelin, oppoſite to the Faces of theſe Orillons; and from whence the Revetements of the Orillons of the Front attacked were breached in the late Siege; otherwiſe, his ſubterraneous Batteries might be of good Uſe, provided they vent well the Smoke.

8. The Ravelins have concave retired Flanks, and ſquare Orillons; ſome of theſe latter have vaulted Batteries which bear, in reverſe, againſt the Breach of the Baſtion, and againſt ſome Part of the great Ditch. Mr. Coehorn was under a Neceſſity of making the Ravelin very ſmall, that its Face, which is directed, in a right Line, to the Angle of

the Shoulder of the opoſite Demibaſtion, might be flanked by the Face of the Orillon; and that more Room might be left, to allow of Lunettes ſufficiently large, and well flanked by the Baſtions: This Ravelin, however, in Conſequence of its Smallneſs, will not admit of a tolerable Retrenchment, nor of a ſizeable and well flanked Redoute. The Flank of the Ravelin, in Conſequence of its being retired, cannot be commanded from the Gorge of the Lunette; and will bear againſt a larger Portion of the great Ditch, and againſt more or leſs of the Battery of the Enemy, which batters in Breach the remote Face of the oppoſite Baſtion, according as the flanked Angle of that Baſtion is more or leſs open. One Cannon, in the right Flank of the Ravelin Walſenaer, (E) bore, in a pretty direct Manner, againſt the whole Battery (R) of the Enemy, which battered, in Breach, the right Face of the Baſtion Pucelle. By Means alſo of the Flanks being retired, the Gorges of the Lunettes are more expoſed to the oblique Fire of the Curtain, and to the Fire of the interior Extremities of the Flanks of the Baſtions.

9. The vaulted Batteries of the Orillons of the Ravelins can be of no great Uſe, ſince the Enemy will always chooſe to make themſelves Maſters of the Ravelin, before they aſſault the Body of the Place; unleſs the Ravelin is open, or not properly retrenched, and that other Circumſtances are the ſame, as in the End of the late Siege: (23) in that Caſe, as the Enemy will be pretty ſure of carrying it at once, and of paſſing the Ditch without † Epaulments, it will

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† An Epaulment is any Screen of Earth, or Maſonry, that is above ſix Feet high, and Cannon proof.

be better to delay the Attack of it, till every thing is ready for aſſailing the Body of the Place, that the Whole may be carried at one aſſault; as Bergenopzoome was in the End of the late Siege: But, I preſume, ſuch a Concurrence of favourable Circumſtances for the Enemy will ſeldom happen, eſpecially where the Advantages of the Beſieged are equally great, as they were to thoſe of Bergenopzoome in the late Siege, Their vaulted Batteries, however, will ſerve as Magazines for Powder.

10. The great reveted Lunettes (H, I, K, L.) in the inward Places of Arms of the covered Way, are, indiſputably, the moſt maſterly, and moſt advantageous Works in this Fortreſs; they are moſt powerfully commanded by the Body of the Place and the Ravelin, and admirably well calculated for the Defence of the Glacis and covered Way; they cannot be taken by open Force, even after a ſufficient Breach is made, and it is with the utmoſt Difficulty they can be reduced by Sap; and after the Aggreſſors have made themſelves Maſters of a Lunette, they will find it impracticable either to lodge in its Gorge, or make any Uſe of it; as was evident in the late Siege of Bergenopzoome. By Means of the great Length of their Demigorges, they render Traverſes, at the ſaliant Angles of the covered Way, unneceſſary; and leave ſo little Room for the Enemy to raiſe Batteries for battering in Breach the Faces of the Baſtions attacked, that they cannot mount above three Cannon unſeen from the flanks of the collateral Baſtions: And if the Angle of the Baſtion that is battered, in Breach, is very obtuſe, the Flank of the adjacent Baſtion, of the collateral Front, will bear againſt every Gun of the breaching Battery of the Enemy; and command intirely that Battery. The Cannon of

the left Flank of the Baſtion Belvidere, ſilenced one Cannon of the four (x) which battered, in Breach, the left Face of the Baſtion Coehorn. The Battery of the French, which battered, in Breach, the right Face of the Baſtion Pucelle, was wholly ſeen from the right Flank of the Baſtion King William, and was intirely commanded thereby; inſomuch, that at laſt, the Enemy could fire one Gun only of that Battery, which lay concealed in the Ditch of the Lunette Utrecht. (1)

11. Another very conſiderable Advantage ariſing from the great Extent of the Demigorges of the Lunettes, is, that the Beſiegers cannot dreſs Batteries againſt the Flanks of the Baſtions attacked, until they are Maſters of the two next adjacent Lunettes to the Front attacked, to which theſe Batteries muſt be almoſt contiguous, and therefore continually liable, as well as the Aggreſſors, who ſerve and ſuſtain them, to dangerous Sallies from theſe collateral Lunettes, the Barrier of the Flank of the Lunette, and the Paſſage at each Extremity of its ſhallow Ditch, being convenient for their Egreſs and Retreat, and the Lodgements and Batteries againſt which they are determined, being at hand; the counter Batteries of the Enemy will alſo be expoſed to a continual Shower of Granades from the collateral Lunettes, which will render it impracticable for the Gunners to ſerve their Cannon; and they will be flanked by the Cannon and Muſquetery of theſe Pieces; this laſt Inconvenience, indeed, they may poſſibly prevent, with ſome difficulty, by raiſing high Epaulments, or Cavaliers, with Footbanks at their Baſes, and the Sand-bags on their Creſts, to intercept the fire of the Lunettes, and command their Faces; which, however, will occaſion them to diminiſh, in ſome meaſure,

the

the Length of their counter Batteries; conſequently, they muſt take in all four Lunettes; which will greatly prolong the Siege, and be very fatal to the Enemy. To theſe Views, (10, 11.) Mr. Coehorn has had particular regard; and has extended the Demigorges of his Lunettes, till the covered Way, and Creſt of the Glacis of ſome of them, come to be badly flanked from the Faces of the Baſtions.

12. In the Angle of the Gorge of the Lunette, there is a round caſemated Tower, or Staircaſe, by which it communicates with the great Gallery of the Counterſcarp, and the great Ditch, which is very commodious for the Egreſs of Sorties, and the Guards of the Lunette and covered Way. Where this Staircaſe opens into the Lunette, it is covered by a * Drum, (x) which may be ſurrounded occaſionally by a paliſadoed Ditch, with a Barrier for the Conveniency of Sorties, and of theſe Guards. The Flanks of the Lunettes, (y) which are retired, or, more properly, the Traverſes of the inward Places of Arms, have alſo a ſecure Sortie, each, into the covered Way: Theſe Traverſes, or Flanks of the Lunette, have their Creſt on a Level with the Top of the Footbank of the Faces of this Piece, that they may not intercept the Fire of the oppoſite Baſtion and Ravelin, which flanks the Inſide of its Breaſtwork. Batteries may be raiſed in the Gorges of the collateral Lunettes, againſt the breaching Batteries of the Aggreſſors; as the Battery which in the late Siege was erected in the Gorge of the Lunette Holland, (L) againſt the Enemy's Battery which battered in Breach the left Face of the Baſtion Coehorn: Their Effect

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* A ſmall Retrenchment compoſed of two Redans; one Redan covers the Opening of the caſemated Stair, in the Gorge of the Lunette, and has an Opening in its ſaillant Angle, which is covered by the other Redan.

will be conſiderable, on Account of the Smallneſs of the Diſtance, and the Direction of their Fire againſt the Enemy's breaching Batteries will be leſs oblique according as the Angle of the Counterſcarp is leſs open. The Lunettes alſo cover, in ſome Meaſure, the high Flanks of the Baſtions, and a conſiderable Part of the Faces of the Baſtions and Ravelins from the Batteries of the Enemy in the Field.

13. The covered Way of Bergenopzoome has no Traverſes at the ſaliant Angles, and it is, undoubtedly, much ſtronger without them; being more open, and expoſed to the Fire of the ſeveral Works, eſpecially of thoſe that flank it, and particularly the Lunettes, by which it is ſo much commanded, and its contiguous Glacis, that it is not to be taken by open Force, even though there is not a ſingle Muſquetier behind its Breaſtwork; nor is it poſſible for the Enemy to compleat their Lodgements on the covered Way, and Creſt of the Glacis, or produce the Lodgement of the Former, beyond the ſemicircular one of the ſaliant Angle, until they are Maſters of the two Lunettes of the Front attacked. In the late Siege of Bergenopzoome, the French attacked the covered Way once by open Force, and loſt a conſiderable Number of their beſt Men to no Purpoſe: Their Lodgements on the Creſt of the Glaſis, and the covered way, were not finiſhed, till about the End of the eighth Week of the Siege, after they had the Command of the two Lunettes (I, K,) of the Front attacked, notwithſtanding the covered Way was long before abandoned by the Beſieged. Hence we diſcover a conſiderable Fault in the Attack of the Enemy, *viz.* their attacking the covered Way of the Baſtions and the Ravelin by open Force, and attempting to extend their Lodgements on the covered Way

beyond

beyond the ſaliant Angles, before they were Maſters of the Lunettes of the Front attacked; regarding theſe only, as retrenched inward Places of Arms: This Error is the greater, becauſe the ſaliant Angles of the covered Way of the Lunettes project further into the Field than thoſe of the covered Way of the Baſtions or Ravelins.

14. The French, had they determined their Attack wholly againſt both theſe Lunettes, (13) after eſtabliſhing Lodgements in the ſaliant Angles of the covered Way of the Baſtions and Ravelin attacked, would have had, ſoon, an Opportunity of puſhing Mines to ruin the great Gallery of the Counterſcarp under the Flanks of theſe Lunettes; which with another Mine, near the ſaliant Angle of the covered Way of each of the Baſtions attacked, behind the Counterſcarp of the Ditch of the remote Faces of theſe Baſtions, to ruin the Counterſcarp there and its Gallery, would cut off the Communication of the Beſieged, from the intermediate intire Portions, oppoſite to the Faces and Angles of the Demibaſtions and the Ravelin of the Front attached; upon which the Beſiegers might have Galleries carried in, as far as the exterior Wall of the great Gallery of the Counterſcarp, to be ready to puſh into it, as ſoon as the Mines were ſprung, and ſo gain and maintain the Command thereof in the Front of the Attack; and conſequently ſecure their Lodgements and Batteries upon the covered Way, and Creſt of the Glacis; they would alſo be enabled, when in Poſſeſſion of the great Gallery, to command the great dry Ditch, and the Ditch of the Ravelin, and ſuſtain effectually their Paſſages acroſs them againſt the Sallies of the Beſieged. To the Error above mentioned, (13) and the Neglect of this

Method, in the French Attack of Bergenopzoome, was owing, in ſome Meaſure, the Length of the Siege.

15. When the ſaliant Places of Arms of the covered Way have no Traverſes, it will be ſufficient, when the Front is ſhort, and the Lunettes ſpacious, to raiſe the Creſt of the Glaſis two or three Feet, occaſionally, at the ſaliant Angle, or to plant thereon Gabions filled with Earth, and diſpoſed in Merlons to ſcreen the Pieces of Cannon which may be mounted in the ſaliant Angles of the covered Way, in the Beginning of the Siege; and their intermediate Ambrazures muſt be cloſed at Top; ſtrong Baſquets may be inverted upon the Footbank, in the Intervals of the Platforms of theſe Cannon for the Muſqueteers to ſtand upon. But when the Fronts are long, or if there are no Lunettes, it will be alſo ſometimes neceſſary to plant temporary Traverſes in the Branches of the covered Way, before the Faces of the Demibaſtions of the Front attacked, which may happen to be expoſed to the ricochet Batteries on the Flanks of the Enemy's Attack; theſe may be compoſed of Gabions filled with Sand-bags, and muſt be taken away as ſoon as the Beſiegers have advanced their Approaches to the Creſt of the Glacis, that the ſaliant Places of Arms, before the flanked Angles of the Baſtions may be more expoſed to the Fire of the Artillery and Muſquetery of the collateral and interior Works, which will be ſufficient for their Defence, (13) and the Guards of the covered Way may be then withdrawn; except thoſe of the inward Places of Arms; the Gabions on the Creſt of the Glacis, at the ſaliant Angles of the covered Way will alſo diſappoint the Effect of Cavaliers in the Trenches. I make no Mention here of placing temporary Traverſes too in the ſaliant Places of Arms of the

covered Way of the Ravelin and Lunettes of the Front attacked, becauſe, I preſume, they will in theſe be always unneceſſary; for while the Aggreſſors are yet remote from the Extremity of the Glacis, ſmall Guards poſted in the ſaliant Angles of the covered Way will be ſufficient for its Defence, and for annoying the Head of the Enemy's Sap, and retarding its Progreſs, (112) the Creſt of the Glacis at the ſaliant Angles being raiſed occaſionally to a proper Height to cover them from the Ricochet; and after the Beſiegers have carried their Approaches to the Foot of the Glacis, they will not hazard the Scouring of the covered Way over the Breaſtwork of their third Parallel; ſo that the Guards of the covered Way before theſe Pieces, may be then augmented, and diſtributed in the whole Extent of its Branches with the utmoſt Safety: Neither can the Aggreſſors ſcour the Branches of the covered Way before the Faces of the Demibaſtions attacked, if the ſaliant Angles of theſe Branches are outfronted by the Extremities of the third Parallel. Mr. Coehorn had, no doubt, theſe Motives in view when he formed the Deſign of the Enceinte of Bergenopzoome.

16. The great Gallery of the Counterſcarp is alſo a maſterly Work, and much larger than thoſe Galleries are generally made, that it may contain a ſufficient Guard for its Defence, and may afford a ſafe Cover for ſome Part of the Guard of the Lunette, eſpecially when the Enemy have obliged them to retire to the Drum of its Gorge. The interior Wall, or Wall of the Counterſcarp, has, in the Intervals of the Pilaſters which ſupport the arched Roof of the Gallery, Loop-holes for Muſquetry, to defend it againſt any Attempt on the Side of the Ditch, and the Baſtions, and

Ravelins againſt ſudden and irregular Attacks: So that the Beſiegers are under a Neceſſity of making themſelves Maſters of it, which can only be effected by the Method abovementioned, (14) The Doors of the Gallery being placed on each Side of the inward Angles of the Gorges of the Lunettes; or they muſt deſtroy it wholly by Mines. From this Gallery Countermines may be puſhed under any Part of the Lunettes, the covered Way and Glacis; and the Enemy's Lodgements and Batteries on theſe Parts, are not ſecure until they have made themſelves Maſters of the great Gallery and Countermines of the Beſieged, in the Method above deſcribed, or by wholly deſtroying the great Gallery in the Front of the Attack by Mines, as the French did in the late Siege; and to which was, in a great meaſure, owing the Length of the Siege.

17. The great Ditch of Bergenopzoome, which is about eighteen Feet deep, is carried down to about one Foot from the Level of the ſubterraneous Summer-water; which will occaſion the Paſſage of it to be more difficult and dangerous, by reaſon there is not a ſufficient Depth of Earth for running a Sap acroſs it; and the Ditch of the Ravelin, that it may allow of Coffres, or interred and covered Lodgements, and be better ſeen from the Face of the Orillon which flanks it, is leſs deep by three or four Feet, by which means it is attended with the Advantages of a dry Ditch, without being liable to have Galleries puſhed under it: By means of the vaſt Depth of the great Ditch, the Countermines which are puſhed directly from the Gallery of the Counterſcarp will have a greater Effect; and by their being ſo near the Level of the ſubterraneous Water, it will be impoſſible for the Enemy to get under them; the Deſcents into the great

Ditch will be executed with more Difficulty; and the breaching Batteries of the Aggreſſors muſt be erected cloſe upon the Verge of the Counterſcarp, whereby they will be more expoſed to the Counterfire of the Beſiegers, which by ſapping the Counterſcarps, will occaſion the Epaulments of theſe Batteries, and ſometimes their Guns, to tumble into the great Ditch; which happened in the late Siege to the Battery which battered in Breach the right Face of the Baſtion Pucelle; the Revetement and Gallery of the Counterſcarp having been deſtroyed before by a Countermine.

18. The covered Way is higher, in moſt Parts of the Circumference, than the Surface of the Field at the Foot of the Glacis; occaſioned, I imagine, chiefly by the Ground, which has been naturally high where the Works are raiſed, and at the Creſt of the Glacis, and low towards the Foot of it; ſo that the Glacis has, in ſome of the Fronts, been chiefly formed by cutting the Earth down towards it Extremity. The high Glacis, then, of Bergenopzoome contributes, in ſome meaſure, to its Strength, tho' not ſo much as by ſome imagined; becauſe the Sand-hills, in the greateſt Part of the Circumference of the Town, afford the Enemy an Opportunity of battering, in ſome Parts, the Body of the Place, from the Field, not only over the Creſt of the Glacis, but alſo over the Ravelins and Lunettes. The French battered the right high Flank of the Baſtion King William from the Field, from two Batteries, whereof one fired obliquely over the Creſt of the Breaſtwork of the Ravelin, and the other more directly, and over the Lunette Frieſland.

19. Mr. Coehorn has given the Baſtions a Demirevetement only, or very little more, chiefly to ſave Expence, and alſo that the Top of the Revetement may not be bat-

tered from the Field; and that it may be more difficult to effect an open Breach by the Cannon of the Enemy upon the Counterſcarp; for where the Slope of the Rampart approaches nearer to a perpendicular Direction, the Wall will be more eaſily ſaped, the Revetement and Part of the Breaſtwork will ſooner tumble down, and an open Breach be more ſpeedily accompliſhed by Cannon; but the Diſadvantage of the large Berm and eaſy Slope of the earthen Rampart overbalances, perhaps, all theſe Advantages, eſpecially in the Conſtruction of Bergenopzoome, and which, no doubt, encouraged, in ſome meaſure, the French in the End of the late Siege, to mount to the Aſſault before the Breaches of the Baſtions were open; for theſe demireveted Ramparts give the Enemy an Opportunity of aſſailing the Baſtions without making an open Breach, and, conſequently, ſome Chance of carrying the Place, without taking the collateral Lunettes, and without commanding the Flanks that ſcour the great Ditch of the Front attacked; whereas, had the Revetements of the Faces of the Baſtions been carried up within eight Feet of the Creſts of the Breaſtworks, with a Berm at top of one Foot only, the Beſiegers would, in all Probability, have been under a Neceſſity of attaching the Miner, which they could not do, with any Succeſs, without making any Epaulment, or a Gallery for him; nor could that Gallery be effected without taking the collateral Lunettes, (11) and commanding and ſilencing the oppoſing Flanks.

20. The Rule that Mr. Coehorn ſeems to have obſerved in determining the Heights of the Ramparts of the Works of Bergenopzoome, and ſuch other of his Works I have had Occaſion to ſee, where the Ditch is dry and narrow, and

the Glacis broad, is to make them ſo high, as that the Cannon of their Faces, where they are not covered by other Works, may be juſt brought to bear over the Creſt of the Glacis, ſo as to raze it; conſequently their Heights will be according to the Breadth of their reſpective Ditches and covered Ways, and the Height of the Creſt of the Glacis above the Level of the Field, and its Breadth, or the Degree of Slope that is given it: So that the Heights of the ſeveral Works of Bergenopzoome, the Ditch of the Baſtion being ſixteen Toiſes broad, the Ditch of the Ravelin eight, and that of the Lunette three; the covered Way of the two former being five Toiſes in Breadth, and that of the latter four, and raiſed three Feet above the Level of the Field; and the Breadth of the Glacis being forty Toiſes, come to be as follows, *viz.* The Baſtion, from the Level of the Field to the Top of its Breaſtwork, twenty one Feet; the Ravelin ſixteen, and the Lunette fourteen.

21. From the Cloſeneſs then of the Works to one another, in conſequence of the Smallneſs of the Fronts, contracted to a certain Meaſure, and of the Narrowneſs of the Ditches; from the judicious Forms and Diſpoſition of the ſeveral Works, and their Proportions with reſpect to the Length of the exterior Side; from the juſt Degree of Heighth which is obſerved in theſe Works, ſo as that the Interior command well the Exterior, and ſo as not to be too much expoſed to the Field; (28) from the determined Depths of the great Ditch, and the Ditch of the Ravelin, with reſpect to the Level of the ſubterraneous Summer-water; and from the Advantages accruing by means of the great Gallery of the Counterſcarp, and the Greatneſs of the Angles of the Circumference, do chiefly ariſe the Strength and Excellence of

the Fronts abovementioned (1) of the Fortification of Bergenopzoome.

22. The Strength of Bergenopzoome doth not altogether depend on the Works of the Place, but, in a great Degree, on the open Communication which it maintains with the Sea and the Land, by means of the Lines of Halteren and Kykinpot, and the Water-ſconce, which Lines are not forcible. By means alſo of theſe Lines, the Enemy are under a Neceſſity of attacking the Town in the Front which is formed by the Baſtions Coehorn and Pucelle, and their intermediate Curtain; whereby ſome Part of the Town, and of the Rampart, and dry Ditch, come to be but very little diſturbed by the Fire of the Beſiegers; convenient for encamping the Garriſon, and for the lying-out Picquets during a Siege. Mr. Coehorn has given a greater Length to the Front which is formed by the Baſtions King William and Pucelle, and their intermediate Curtain, than to the one which was attacked in the late Siege, becauſe it is ſtronger by Situation, having ſome ſtagnating Water at the Extremity of its Glacis, and the Field before it flanked by the Lines of Halteren; and as theſe Advantages are chiefly in favour of the Baſtion King William, ſo it is ſmaller and weaker than either of the two Baſtions on its Right: The right Flank of the Baſtion King William alſo bears againſt a greater Portion of the Counterſcarp before the right Face of the Baſtion Pucelle, than if the Front were ſhorter. (10)

CHAP. II.

A brief Narrative of the Faults which were committed in the Defence of Bergenopzoome, in the End of the late Siege; and of the Precautions which ought to have been taken to prevent Surpriſes, and to oblige the Beſiegers to carry on their Attack regularly; together with an Eſtimate of the Number of Days to which the Defence might have been protracted, from the Day on which the Town was ſtormed, excluſive of the Defence of ten Weeks it actually made.

23. IN my Journals, for his Royal Highneſs the Duke of CUMBERLAND, of the Attack and Defence of Bergenopzoome, of the 13th and 14th of September, 1747. N. S. after the Beſiegers had opened their Batteries to batter in Breach, I demonſtrated that they could not dreſs Batteries againſt the Flanks of the Baſtions attacked, in order to raiſe Epaulments, or Screens, for paſſing the dry Ditch, without firſt making themſelves Maſters of the Lunettes Holland and Frieſland (L, H) of the collateral Fronts (11): And as the Enemy ſeemed to neglect this Method, which was the regular and moſt prudent, had the Defence been brave * and judicious, I concluded in theſe Journals, that the Enemy had ſome extraordinary Deſign in view, which I could not diſcover, imagining they would attempt nothing raſh or precarious in the Face of a ſtrong Garriſon, and which could

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* I do not mean by this to inſinuate any Want of Bravery in the Garriſon, for I am ſenſible of the contrary, but that there was not a good uſe made of their Bravery.

be ſoon reinforced from the Lines of Halteren; tho' I was ſenſible of the Neglects and Errors in the Defence, which I ſhall preſently mention; which, with ſeveral others that were committed in the Courſe of the Siege, I took notice of in the abovementioned Journals; neither did any of the Dutch Engineers of Experience diſcover, that the Enemy's Deſign was to mount to the Aſſault, uncovered by Epaulments from the Fire of the Flanks of the Baſtions attacked, and without dreſſing Batteries againſt theſe Flanks; which, however, might have been diſcerned from the Enemy's Method of Attack in the End of the Siege, compared with the following Circumſtances, which concurred to favour ſuch a Deſign, and to encourage the Aggreſſors to purſue that ſpeedy and irregular Way of Attack, which were theſe: The Counterſcarp of the Front attacked being almoſt wholly ruined by Mines and Countermines, afforded the Enemy a Number of eaſy Deſcents into the great Ditch, and the Ditch of the Ravelin; theſe Ditches were dry; the Ravelin had its Revetement breached, and its Gorge unretrenched; the Faces of the Demibaſtions attacked and the Faces of their Orillons had conſiderable Portions of their Revetements, or Walls of Maſonry battered down by the Enemy's breaching Cannon, and the earthen Ramparts and Breaſtworks over the breached Revetements were roughed by the Cannon, ſo as to make their Aſcent practicable; the Orillons were low, and therefore of eaſier Aſcent, and the Sorties or Overtures of their high concave Flanks, which interpoſe between their Gorges and the Terreplain of the Baſtions, were not ſecured by any Barrier; the Berm of the Rampart of the Place was large, ſo as to give the Aſſailants an Opportunity of making ſome little Halt, after gaining the Top of the ruined Revetement, in order to form themſelves, in ſome meaſure, on the Berm, and to aſcend the earthern Rampart together, and ruſh on to the Aſſault in a cloſe and firm Body; but the principal Circumſtance, and which promiſed certain ſucceſs to the Beſiegers was, that the Flanks of the Baſtions attacked were neglected by the Beſieged; the high Flank of the Baſtion Coehorn having not one Cannon mounted therein, againſt the Ditch and Face of the oppoſite Baſtion, * altho' the Breaſtwork was perfectly good, having been lately before repaired, and its Ambraſures filled up; and the low Flank had only two ſmall Pieces of Cannon, which were long before ruined by the Bombs of the Enemy. The high Flank of the Baſtion Pucelle had four Pieces of Cannon, two of them were diſmounted by the Enemy's Bombs, the other two, which were planted in the Flank of the Gorge againſt the Battery which battered the Face of the Baſtion Coehorn in Breach, were ſtill ſerviceable; but the Beſieged, it ſeems, made no uſe of them for ſcouring the great Ditch, when the Aſſault was given, for tho' neither of them could be brought to bear againſt the Foot of the Wall of the Face of the oppoſite Baſtion, yet the great Ditch was almoſt wholly expoſed to their Fire (4). The low Flank of Pucelle had indeed five ſmall Pieces of Cannon, which were planted therein ſo long before there was Occaſion for them, that they were alſo moſtly ruined by the Bombs of the Enemy; and ſuch of them as might have been of ſome uſe were neglected. The high Flank, indeed, of Coehorn was expoſed in Re-

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* There was one Cannon mounted in the Angle of the Flank of the Baſtion Coehorn, againſt the Lodgement of the Enemy in the Breaſtwork of the left Face of the Lunette Utrecht; which could not much contribute towards the Defence of the Ditch of the oppoſite Baſtion.

verſe to the Fire of Cannon and Hobitz in Ricochet, becauſe there was no Traverſe or Epaulment raiſed parallel thereto, at the Extremity of its Platform, as the one which was thrown up behind the oppoſite high Flank of Pucelle, which diſappointed wholly the Effect of the Ricochet; the Fire of the Artillery that flanks them is alſo eaſily evaded, by raiſing Traverſes in the Intervals of the Ambraſures: So that the Effect of the Ricochet, in the Body of the Place, is very little more than to oblige the Beſieged, by raiſing Traverſes, to leave leſs Room for Cannon in the Faces and Flanks of the Work; and even that it does but in a ſmall Degree, becauſe the Traverſes, tho' made pretty thin, are ſufficient to reſiſt the Ricochet, and when ſhattered by Bombs are ſoon repaired †.

24. Had the Beſieged then made a right Uſe of the Flanks of the Baſtions, it would have been impoſſible for the French to ſucceed in their Aſſault, eſpecially as the Breaſtworks over the breached Revetements were intire, which were infinitely preferable to the beſt Retrenchments that can be raiſed with-

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† In the Outworks, the Ricochet may have an Effect ſtill more advantageous to the Beſiegers, *viz.* by obliging the Beſieged to make Traverſes in them, give the Beſiegers an Opportunity of covering the Head of their Sap from the flanking Fire of the interior Works, by directing it towards the Traverſes. Therefore, the Beſieged, if they are under a Neceſſity of making Traverſes in the Ravelin, and Lunettes, muſt not fail to level them, or to take them away, as ſoon as the Approaches of the Enemy have reached the Creſt of the Glacis; becauſe they will then have no further Occaſion for them, ſince the Aggreſſors will not venture to play the Ricochet over their own Lodgement on the Creſt of the Glacis, into theſe Works; and that theſe Traverſes may not afford any Cover for the Head of the Sap of the Enemy, which muſt otherwiſe be puſhed on, in theſe Works, with the utmoſt Difficulty and Danger. The Impoſſibility of ſcouring, without imminent Danger to the Beſiegers, the Outworks of the Front attacked by the Ricochet, after the Lodgement of the Glacis is begun, was manifeſt in the late Siege, nor were the Beſieged under any Neceſſity of raiſing Traverſes in the Ravelin, or Lunettes attacked, or in the covered Way.

in the Baſtions againſt the Aggreſſors; for if they are ſtopt but a very little by the Guards of the Baſtions, the Fire of the Cannon and Muſquetry of the Flanks will ſoon clear the great Ditch of the ſucceeding Aſſailants: Nor was it difficult in the Aſſault of Bergenopzoome, to ſtop their Carrier, by reaſon they mounted, or rather ſcrambled up to the Aſſault, with much Difficulty, the Breaches being very imperfect. Beſides, the Picquets of the Garriſon, or at leaſt two thirds of them, in place of being ſtationed in the Streets, near the Center of the Town, might have been diſpoſed of as follows; for there was nothing to be feared but from the Side of the Front attacked, *viz.* one half of them divided equally in the Baſtion Belvidere, and the Baſtion to the Left of Wou Port, on each Flank of the Front attacked, where they might have lain under Planks laid ſloping againſt the Breaſtworks, on the Side of the Fire of the Enemy, with the greateſt Safety; and the other half might have been ſtationed in the Archways of the Poſterns of the Curtains, and the low Flanks of the Front attacked, and its collateral Fronts; where they would have been at hand to ſuſtain the Guards of the Baſtions, whenever the Aſſault was given: Whereas, in the ſtorming of Bergenopzoome, the Picquets were of no manner of uſe. In order then to give a juſt Idea of the Strength of Bergenopzoome, which is not to be determined by the Defence it made in the late Siege; I ſhall inſert the following Eſtimate, which I tranſmitted to Colonel Napier, for his Royal Highneſs's Peruſal, immediately after the Loſs of that ſtrong Fortreſs.

25. Since the French, if their Aſſault had been repelled, or prevented, by a diligent Uſe of the Precautions abovementioned, (24), muſt have been obliged to carry large

Epaulments over the dry Ditch, to the Breaches of the Demibaſtions of the Front attacked, which they could not do, without firſt dreſſing Batteries againſt the Flanks of theſe Demibaſtions to ruin and command their Defences; and as ſuch Batteries cannot be raiſed, unleſs they are Maſters of the collateral Lunettes (11) ſo the the Beſiegers muſt in that Caſe have been under a Neceſſity of taking them.

In order to reduce theſe Lunettes, (H,L,) they muſt begin, (*a*) by puſhing direct Saps from the third Parallel to the ſaliant Angle of the covered Way of each Lunette, and take the ſaliant Angles of the covered Way of both theſe Lunettes, I ſhall ſuppoſe, by open Force, after running and blowing a Fougaſs, or ſmall Mine only, under each of them (for they were not countermined) to deſtroy the Paliſadoes, and render it more eaſy to eſtabliſh Lodgements which ſhall embrace theſe Angles; they muſt alſo make a ſmall Lodgement on the Creſt of the Glacis, at the ſaliant Angle of the covered Way of each of the ſaid Lunettes, to ſuſtain their Lodgements on the ſaliant Angles of the covered Way: For this Work we may allow, at a moderate Computation — Days. 6

(*b*) For puſhing a Mine under the ſaliant Angle of each of theſe Lunettes, and making, by means thereof, a compleat Breach in each of them, and lodging in the Breaches — 3

Sum 9

Days.

Brought over 9

(*c*) The Enemy, in the mean time, being buſied in carrying a Trench of Communication from the Lodgements on the Creſt of the Glacis at the ſaliant Angle of the covered Way of each Lunette, in a right Line to the Lodgement of the Creſt of the Glacis at the ſaliant Angle of the covered Way of each of the Baſtions (AB) attacked; the better to ſuſtain the Works above ſpecified (*a*, *b*.) againſt Sorties, and to plant Mortars and Pierriers behind them, for throwing Bombs, Stones and Granadoes into the ſaid Lunettes: Some Allowance might alſo be made, at this time, for the Effect of Sallies, which however, ſhall not be ſtated, as I propoſe that this Eſtimate ſhall be as moderate as poſſible. The Enemy, from their Lodgement in the Breach (*b*), will command the Lunette, as far as its tranſverſe Retrenchment, or to the Drum in its Gorge, if the former is wanting †.

(*d*) As the Ditches of the Lunettes, their Breaſtworks, and Platforms are flanked and commanded, as much as poſſible, by the Faces of the oppoſite

Sum 9

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† There is an abſolute Neceſſity of running a tranſverſe Retrenchment in each of the Lunettes of the Front attacked, from the Extremities of their Faces, to cover their Flanks, that they may not be commanded from the Lodgements of the Enemy in the Breaches of the ſaliant Angles; which would give them an Opportunity of compleating their Lodgements and Batteries on the covered Way, without being under a Neceſſity of making themſelves wholly Maſters of the Lunettes.

Days.

Brought over 9

Baſtions and Ravelins, and by the tranſverſe Retrenchments of their Gorges, the Beſiegers will be obliged to blow up by Fougaſſes, or ſmall Mines, the Breaſtworks and Ramparts of the Lunettes, as they advance their Sap, and puſh it on in the Excavations of theſe Mines *; raiſing always Traverſes, when neceſſary, at the Heads of the Saps, to cover them in the Day from the flanking Fire of the Baſtions and Ravelin, until they come to the Gorges of the Lunettes, within the Extremities of their tranſverſe Retrenchments, each of the Extremities of which is joined, I ſhall ſuppoſe, by a ſmall Trench, or interred Lodgement, running parallel to the Flank of the Lunette; which Intrenchments and interred Lodgements they alſo blow up at the Angles formed by their Junction, and join the Extremities of their Lodgements in the Faces of the Lunette, by a tranſverſe Lodgement acroſs the Gorge of the Work: They will then have the Command of the whole

Sum 9

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* The Beſiegers carried on in this manner their Lodgements in the right Face of the Lunette Utrecht, on the Side of the Ravelin. They muſt alſo have been obliged to run it in the ſame manner along the left Face, and with ſtill greater Difficulty and Danger, had not the Beſieged abandoned the right Face of the Baſtion Pucelle, which flanked and commanded it in the ſtrongeſt Manner, by reaſon the principal Ricochet Battery of the Enemy ſcoured the Inſide of the Breaſtwork of the ſaid Face of Pucelle: But the Effect of the Ricochet might have been eaſily evaded (23); which was evident from a Bomb Battery in this very Face of the Baſtion near the Angle of the Shoulder, behind a thin Traverſe which covered the ſaid Battery from being in the leaſt incommoded by the Ricochet.

Days.

Brought over 9

Lunette, except the Drum which covers its caſemated Communication with the great Ditch, and great Gallery; provided their tranſverſe Lodgement is without the Verge of the Excavation of the Countermines of the Gorge of the Lunette; which was the Caſe in the late Siege, becauſe theſe Countermines were not puſhed far enough. For this Work then, ſuppoſing it to be carried on in both Lunettes at the ſame time, 7

(*e*) But if the Beſiegers don't take the Drum of the Lunette, by making themſelves Maſters of the Countermines of the Gorge, or ruin it by blowing theſe Countermines, or obliging the Beſieged to blow them, they will be ſtill, and continually liable to Sallies, which, if well deſigned and conducted, may give the Beſiegers a deal of Trouble at this time, and alſo oblige them to keep ſtronger Guards in their Lodgements of the Lunettes, which will occaſion their Loſs to be proportionably greater, ſince they are then ſo much expoſed to the Fire of the Artillery and Muſquetry of the Body of the Place, and the Ravelin. They will alſo be liable, while the Beſieged are Maſters of the Drum, to have Mines puſhed under their Lodgements in the Lunettes, and under their Batteries that batter in Breach the Baſtions and Ravelin attacked. For puſhing Mines then in order to make themſelves Maſters of the Drum of

Sum 16

of

Days.

Brought over 16

of each Lunette; or rather to ruin it (39) by blowing its Countermines. 7

A conſiderable Allowance might alſo be made for puſhing Galleries with Branches under the Ground of the counter and breaching Batteries on the Counterſcarp, in order to maintain the Command of that Ground, and ſecure theſe Batteries: For the Beſieged might have ſtill maintained Communications, by means of Caponieres, or double covered Ways, in the dry Ditch, with ſome intire Portions of the great Gallery, near theſe Batteries, becauſe the Beſiegers did not make themſelves Maſters of it in the Method above-mentioned (14); which, nevertheleſs, ſhall not be ſtated, that we may not ſeem to exaggerate any thing in our Eſtimate of theſe Attacks.

(*f*) The Beſiegers, in the mean time, and while they are mining under the Gorges of the Lunettes (*e*), may be compleating their Lodgements on the Creſt of the Glacis of the covered Way of the Faces of the Baſtions attacked, which regard the ſaid collateral Lunettes; and under Cover of theſe Lodgements, raiſe their Batteries againſt the oppoſite Flanks, and join the ſaid Lodgements with thoſe of the Glacis of the collateral Lunettes, at the intermediate re-entring Angles, the better to ſuſtain theſe Batteries; they may alſo be employed, while

Sum 23

Days.

Brought over 23

they are puſhing the Mines beforementioned (*e*, *f*.), in raiſing a Battery to batter in Breach the Face of the Ravelin; and in battering the Defences of the Orillons of the Demibaſtions of the Front attacked, which defend the Ditch and Breach of the Ravelin; and likewiſe in making a Deſcent into this Ditch, and carrying an Epaulment to the Foot of the Ravelin.

(*g*) For making themſelves Maſters of the Ravelin, which was well countermined, and ſuppoſing it alſo to be well retrenched. 6

The Enemy, in the mean while, being alſo employing in ruining the Flanks of the Baſtions attacked, and diſmounting their Cannon; and in battering theſe Baſtions in Breach, and making a ſcreened Deſcent into the great Ditch oppoſite to the Breach of each Baſtion.

(*h*) For compleating the Screens for covering the Paſſage of the great Ditch, to the Foot of the Breaches of the Baſtions, and lodging in the Breaches, and puſhing a Mine under the Face of each Baſſtion to make the Breaches ſufficiently open. 5

Total 34

26. So that the whole amounts to 34 Days; without making any Allowance for the Defence of the Baſtions by Retrenchments, or for Faults committed in the Attack, or for Sorties; or for the Effect of Counter-approaches, which

might have been practiſed with Succeſs in the Beginning of the Siege, becauſe the Gariſon, including the Troops of the Lines, was ſtrong; and the great Lunettes of the covered Way, and the Lines of Halteren and Kykinpot were conveniently ſituated for flanking and ſuſtaining the Trenches of Counter-approach; and for covering grand Sallies; and conſequently the Length of the Siege from the Beginning, or breaking Ground, might have amounted to 104 Days, at a very moderate Computation: And as the Works above-ſpecified are the moſt dangerous to be executed in the Courſe of a Siege, they muſt neceſſarily have been very fatal to the Beſiegers, and probably have obliged them at length to raiſe the Siege, or given our Army an Opportunity of raiſing it, when that of the Enemy was weakened by the Length and Fatality of it.

CHAP. III.

Remarks which were made in the late Siege of Bergenopzoome, tending to determine ſome Points of Importance in Fortification.

27. THE common Notion, that the Defences of Works may be ruined irreparably from the Field, ſeems to have taken its Riſe among unexperienced Authors of Books of Fortification, ſince theſe are naturally apt to conceive indiſtinct Ideas of many things in the Practice of the Art. I am the more ſurpriſed they ſhould fall into this Miſtake, becauſe Mr. Vauban makes particular Mention of the contrary *. At the Siege of Bergenopzoome, it was

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* Vauban Chap. 10. Des Batteries de Cannon. Pour faires des Batteries qui puiſſent faire l'effect qu'on ſe propoſe, qui eſt, de demonter les canons de la place &

evident, that the Breaſtworks of the Pieces attacked could be repaired as often, and as quickly, as they were damaged by the Enemy's Cannon in the Field. This was ſtill more remarkable in Fort Rover, a ſmall ſquare Fort with four Baſtions, on the Lines of Halteren, which had the Face of one of its Baſtions battered, from a Battery of the Enemy which was erected on high Ground, and at a ſmall Diſtance, for about fourteen Days ſucceſſively, beſides two Mortars playing continually into it; and yet the Breaſtwork of the Face of the Baſtion was every Morning in as good a Poſture of Defence, as on the firſt Day of the Attack, and its Cannon were played with as much Spirit. The Lunette which is advanced before the Curtain was ſtill leſs remote from the offenſive Battery of the Aggreſſors, to the Fire of which it was likewiſe ſubjected; but its Parapet, which was alſo bound and reveted with Faſcine-work, and repaired with Diligence, rendered wholly fruitleſs the Efforts of the Enemy. The ruining of the Defences then, is not ſo eaſily accompliſhed as thoſe Gentlemen have imagined; they may, however, be commanded, in a great meaſure, by a ſuperior Number of heavy Cannon, and Bombs together.

28. Practical Engineers know alſo well, that the Enemy cannot make uſe of any of their diſtant Batteries of Cannon againſt the Defences of the Works of the Front attacked, after they have begun their Lodgement on the Creſt of the Glacis, except the Ricochet ones on the Flanks of their Attack; for they will not venture to fire over their own Lodge-

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&c de chaſſer l'Ennemi de ces defenſes. Pag. 75. Apres ces Batteries il n'en faut Pas d'autres que celles du Chemin couvert: car il n'arrive point qu'un Parapet a l'epreuve ſoit aſſez rasé pourque l'on ne s'en puiſſe plus ſervir.

ment on the Creſt of the Glacis, nor indeed over the Breaſtwork of the third Parallel, unleſs the Ramparts of the Works overtop the Glacis too much, as thoſe of the Body of the Place at Boiſleduc, or unleſs their Batteries are erected on high Ground. At this Juncture then, and before the Aggreſſors have erected their Batteries on the Glacis and covered Way, the Beſieged have ſufficient time to repair the Defences of the Works attacked, eſpecially if there are ſome Countermines to keep the Enemy ſome time in play. At Bergenopzoome there was nothing to hinder the Beſieged from having the Breaſtworks of the Body of the Place in as good a Poſture of Defence the Day before the Beſiegers opened their Batteries to batter in Breach, as on the firſt Day of the Siege; altho' the Beſiegers, after the Fire of their direct Batteries in the Field againſt the Front attacked ceaſed, increaſed conſiderably the Number of Mortars, Hobitz and Cannon in ricochet, from whence they fired inceſſantly. But if the Beſieged are alert and well conducted, they may repair the Breaſtworks at all times of the Siege, in the Nights eſpecially, as we have already obſerved with regard to Fort Rover (27), in Defiance of all the diſtant Artillery of the Aggreſſors; provided they are well ſtored in Gabions and Faſcines; eſpecially the latter, which bind and ſtrengthen the Breaſtworks ſurpriſingly well againſt the Effect of the Enemy's Cannon.

29. In Places where there is not a ſufficient Quantity of Faſcines and Gabions amaſſed before the Siege, and which may be wholly inveſted, it will be more difficult to keep the Breaſtworks in repair; but in Defect of Faſcines they may ſubſtitute Clay mixed up with Straw, and moulded in form of Bricks, if any Clay can be found in the Place.

30. From what is ſaid then (27 to 29), I think it is pretty evident, that the great Argument in favour of making Outworks equal in Height to the Body of the Place and to one another, that the Defences of all the Works may not be ruined at once from the Field, evaniſhes; beſides, I cannot ſee for what reaſon the Votaries of this Hypotheſis would have an exterior Work juſt as high as the next interior, when the End they propoſe may be anſwered, not only equally well, altho' the exterior Work is four or five Feet lower than the interior, but the interior will alſo, in Conſequence of its ſuperior Height, command much better the exterior Work; for the Enemy can very little hurt the Defences or Cannon of a Work, when two or three Feet only of its Breaſtwork appear over the Creſt of the Piece that covers it, at the Diſtance of 200 Toiſes from the ſaliant Angle of the covered Way; and it is certain that a powerful Command of the exterior Works by the interior ones, is the moſt advantageous Circumſtance that can attend a defenſive Front (28, 39, 75, 78.), which ought therefore to be preferred to every other Conſideration, and greatly to the trivial one abovementioned.

31. In the late Siege of Bergenopzoome, it appeared, that battering the Flank of a Baſtion obliquely from the Field is to no Purpoſe; the right high Flank of the Baſtion King William was battered above twenty Days ſucceſſively, in † Eſcharp, by a Battery of three Cannon, which was erected on a Sand-hill, and fired over the Creſt of the Ravelin; and alſo for ſome Days, and leſs obliquely, by a Battery of four Cannon, which was likewiſe erected on high

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† Eſcharp, at a very acute Angle.

Ground, and fired over the Breaſtwork of the Lunette Frieſland, without diſmounting one Cannon of the ſaid Flank of the Baſtion King William, or incommoding much the Beſieged: Hence, the Advantages ariſing from Orillons are probably much leſs than is generally imagined, and perhaps overballanced by the Loſs of the Room of one or two Cannon which the Orillon commonly takes up, more eſpecially ſince theſe Cannon bear at the greateſt Angle againſt the Face and Breach of the Baſtion; and by the Shoulders of the Baſtion being rendered leſs capacious, its Gorge narrower, and the Lines of Defence a little ſhorter, in conſequence of the retired Flanks (72). One Cannon, indeed, of the low Flank is covered, by means of the Orillon, from the Fire of the Counterbattery of the Aggreſſors on the oppoſite Counterſcarp; but this concealed Gun, immediately behind the Orillon, may be eaſily diſmounted, or ruined by Bombs; therefore this Intention of the Orillon is likewiſe imaginary: Beſides, it is alſo evident, that the Enemy cannot hurt, from the Field, the Cannon of the Flanks of the Baſtions, ſince there is no Occaſion to plant a ſingle Gun in any one of the Flanks until the Approaches of the Beſiegers are carried to the ſaliant Angles of the covered Way (28); and any Damage the Breaſtworks of the Flanks may have ſuffered by the Fire of the Field Batteries, is ſoon and eaſily repaired.

32. It will be urged, perhaps, in favour of the Orillon, that, if the Gun immediately behind it is caſmated, and by Conſequence covered from the Bombs as well as from the Counterfire of the Cannon of the Beſiegers, the Advantages that will acrue by means thereof to the Beſieged will be of the utmoſt Importance, ſince that Gun will bear againſt the

Breach of the Face of the Baſtion in reverſe. The Orillon, in order to cover ſufficiently the continuous Flank-Gun from the Fire of the oppoſite Counterbattery, muſt have its Retreat directed to the Face of the oppoſite Demibaſtion at fourteen or fifteen Toiſes from the ſaliant Angle, and ſtill more ſo if the Angle of the Baſtion is very obtuſe; conſequently a very inconſiderable Part, only, of the great Ditch before the breached Face of the Baſtion will fall within the Line of Bearance of that Gun, which therefore will impede little or nothing the perfecting of the Paſſage of the great Ditch to the Foot of the Breach; which Paſſage, or Epaulment, being once effected, it will be eaſy to attach the Miner under Cover thereof; the Mine being accompliſhed and ſprung, the Excavation thereof, which forms the Breach, will cover the Aſſailants, as they mount to the Aſſault, from the Fire of the concealed and caſmated Gun next the Orillon; but if the Cannon have already made a mountable Breach, there will be no Occaſion to attach the Miner, becauſe one Gun which bears only againſt the Face of the Baſtion will not be ſufficient to diſappoint the Aſſault; neither will the Beſieged, it is to be preſumed, put much Confidence in it, ſince the Hazard and Danger they riſque in ſo doing is very great (51.).

33. Notwithſtanding the Batteries of the Beſieged, at Bergenopzoome, of the right Flanks of the Baſtion King William, and the Ravelin Walſenaer (E), which bore in a pretty direct manner againſt the Enemy's Battery (R) which battered in Breach the right Face of the Baſtion Pucelle, were not commanded nor incommoded by any Battery of the Aggreſſors, yet the French Gunners, by repairing

ing every Night that breaching Battery, with indefatigable Labour, and ſerving with Bravery and Alertneſs, ſuch of the Cannon as were not ruined, or diſmounted, and remounting thoſe that were ſo, or planting ſufficient ones in their room, found means, at length, to make a compleat Breach in the Demi-revetement of the Face of the Baſtion, ſo as to make the Rampart mountable, with ſome Difficulty. Hence we ſee that a Battery, battering in Breach, may have in a great meaſure its Effect, notwithſtanding it is commanded by other Batteries of the Beſieged, which cannot be ſilenced by the Beſiegers.

SECTION II.

Of REGULAR FORTIFICATION.

CHAP. I.

An Inveſtigation of the particular length of Front, in Fortification, which is the moſt advantageous, when ſo ſituated as to derive little or no Defence from its collateral Fronts; and alſo of the beſt Length of Front for a regular Enceinte that is intended to have Ravelins, and great Lunettes in the covered Way.

34. THE Degree of Strength † of the moſt ſimple and ſymmetrical Front of Fortification, and of a ſimple and regular defenſive Outwork, and by conſequence of a regular ſtrong Front, which is compoſed of both theſe united and regularly diſpoſed, ſeems incapable of being demonſtrated geometrically, or mechanically, or by any Method that will amount to a mathematical Certainty; becauſe the Attack and Defence conſiſt in a Variety of Circumſtances that can neither be exactly determined, nor admit of being wholly reduced under certain and general Rules; and theſe too are ſtill diverſified by the particular and dif-

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† By the Degree of Strength, or reſiſting Force of a defenſive Work, which I ſhall frequently have Occaſion to mention in the Sequel, I mean the determinate Space of Time during which it is capable of being defended againſt a regular Attack.

ferent Management of the Attack and Defence by Engineers of different Capacities; by the Method of the Front attacked, the Meaſure of the Angle of the Circumference, and the Length of the exterior Side; far leſs capable then will be the irregular Works and Fronts in Irregular Fortification of admitting of ſuch Demonſtration. We may, nevertheleſs, approach very near the Truth, by rightly conſidering thoſe various Circumſtances generally ariſing in the Attack and Defence of regular Fronts, and by making an Eſtimate of the Times which the ſeveral Works of the Beſiegers take up, founded on Experience; whereof we have given a Specimen (25, 26,): And in Attacks of irregular Fronts, by obſerving how the Circumſtances vary, depending on the particular Length of each of the Fronts concerned in the Defence, the Meaſures of the Angles of their exterior Sides, and their particular Methods; and the Quality of the Field in their Front, relative to the ſeveral Particulars attending it, which can affect the Attack; and making an Eſtimate of the ſeveral Works which muſt neceſſarily be carried on by the Beſiegers, before they can be Maſters of the Fortreſs. In this manner nearly, I propoſe to purſue the following Enquiries (Chap. 1, and 14. Sect. 2), which tend to aſcertain ſome Points that are of the higheſt Importance to the well underſtanding both of Regularand Irregular Fortification, *viz.* the beſt Lengths that can be aſſigned to the exterior Side, for ſimple, ravelined, and more complex defenſive Fronts, according as they are applied to regular Encloſures of different Diameters, or as any particular Front is advanced ſingly before the Enceinte, or more prominent than its collatteral Fronts; they alſo tend to diſcover the Quantity of Strength which each Front is poſſeſſed of, and the Proportion it bears in Enceintes of different Conſtructions, but equal Diameters, to their reſpective Expences, and their Degrees of Simplicity. Theſe Particulars are abſolutely neceſſary to be known, at leaſt near to Truth, before we can pretend to give any tolerable juſt Conſtructions of Regular or Irregular Fortification. I do not, however, propoſe to trace them juſt in the Manner, and with all the Minuteneſs above mentioned, by making particular Eſtimates of the Times required for executing the ſeveral various offenſive and covering Works throughout the whole Courſe of an Attack; judging it ſufficient, in the Proſecution of theſe Enquiries, to compare the ſeveral Parts of the Fronts in queſtion, and their reſpective Advantages and Diſadvantages, and from thence to exhibit a general View of their Degrees of Strength, with reſpect to each other; eſpecially as by this Method, the whole will be clear and conciſe, which otherwiſe would be tedious and perplexed. In this Chapter I ſhall inveſtigate the Particulars only which are ſpecified in the Contents prefixed thereto, and ſhall refer the remaining Part of the Subject to be treated of in the 14th Chapter of this ſecond Section, becauſe the Narrative of the Defences of the eighth Method is an Introduction to it, and muſt therefore be previouſly given.

35. In order to this, let us firſt compare the Fronts A, B, Fig. 1. and C, D, Fig. 2. Pl. 2. the firſt of 160 Toiſes, and the latter of 200, their Perpendiculars and Faces being equal, and the Length of the Perpendicular 30 Toiſes, and the Face 50; the Flank E conſequently, of the long Front CD comes to be 30 Toiſes, and that of AB $23\frac{1}{2}$; the former having $6\frac{1}{2}$ Toiſes more, in conſequence of the Exceſs of the length of the Front CD above that of

the Front AB: The ſaliant Angle of the Baſtion of the long Front CD meaſures 147 Degrees, and that of the ſhort Front 139 Degrees only, by reaſon the Line of Defence of the former, in conſequence of its greater Length, makes a ſmaller Angle with the exterior Side.

36. But the Faces of the Demibaſtions of the long Front CD muſt be produced each 10 Toiſes inwards, from I to K, that they may have each a Length of 60 Toiſes, which Count Pagan has very juſtly aſſigned them; for the Ravelin muſt otherwiſe be either badly flanked, ſince its Face will make a large Angle with the Face of the Baſtion, or it muſt have an immenſe Length of a Capital, to occaſion its Faces to be flanked more directly from the oppoſite Baſtions: If its Face makes a very open Angle with the Face of the Baſtion, it will not only be flanked thence more obliquely, but the covered Way and Creſt of the Glacis before the Face of the Baſtion will alſo be flanked more obliquely by the Face of the Ravelin; and if the Ravelin is brought to be flanked more directly from the Baſtions, by extending its Capital, that will occaſion it to be a great deal too ſaliant, and conſequently eaſily approached, and badly commanded by the Place; therefore it is better to make the flanking Defences of the Ravelin as direct, in this long Front, as is conſiſtent with other Conſiderations, by lengthening the Faces of the Baſtions, and contracting the Gorge of the Ravelin (64): But if the Faces of the Demibaſtions of the long Front CD are made 60 Toiſes long each, the Flank F will come to have no more than $24\frac{1}{2}$ Toiſes in length, which is only one Toiſe more than that of the ſhort Front (AB); which, however, is ſufficiently extenſive to anſwer, in every reſpect, the Object of its Conſtruction (67, 69).

37. Suppoſe now each of theſe Fronts to have a Ravelin whoſe Faces produced inwards ſhall cut the Faces of the Demibaſtions, at 5 Toiſes from the Angles of their Shoulders, and the Capital of the Ravelin of the long Front CD to be produced into the Field, until the Angles formed by its Faces and the Faces of the oppoſite Demibaſtions come to be equal to thoſe which are formed by the Faces of the Ravelin of the ſhort Front and its Demibaſtions; ſo as that both Ravelins may be flanked equally direct, as thoſe in Fig. 1ſt and 2d. Conſequently the Ravelin, as well as the Demibaſtions of the long Front CD will be much larger than thoſe of the ſmall Front AB; therefore the Exceſs of the Expence of a Series of ſhort Fronts above that of a Series of long ones, both conſtructed in this Manner, on two ſtraight Lines of equal Lengths, will be inconſiderable.

38. The Angle C of the Baſtion of the long Front, is larger than that of the ſhort Front, which will occaſion the Counterſcarp G to be ſomewhat more oblique, in reſpect of the Flank L, and a little more of it to be ſeen from thence than in the ſhort Front; and the Faces of the Baſtions of a Series of long Fronts alſo to be ſcoured with more Difficulty by the Ricochet, by reaſon the ricochet Battery muſt approach nearer to the collateral Fronts; but the Difference from thence ariſing between the Strengths of theſe Fronts (AB and CD) will be inconſiderable.

39 The Baſtion of the long Front being larger than that of the ſhort one, has more Room for Traverſes to evade the Ricochet, and for Retrenchments. The Face of the Baſtion of the ſhort Front has 50 Toiſes in length, about 7 Toiſes more than that of any of the Baſtions above-mentioned of Bergenopzoome, which is therefore of ſufficient

Extent to flank and command well the Outworks and the Field, after affording enough of Space for Traverſes; and any Advantages that may ariſe to the long Front, in conſequence of the greater length of the Face of its Baſtion, is overbalanced a great deal by the Advantages which the ſhort one acquires by having the Face of the Baſtion, its great Ditch and Counterſcarp more powerfully commanded by the oppoſite Flank, becauſe its Line of Defence is ſhorter by 30 Toiſes than that of the long Front, beſides other Advantages that are ſpecified in the Sequel (41); for the Efficacy of the Fire of Artillery and Small Arms againſt the Approaches of the Enemy, increaſes in a very great Proportion as the Diſtance diminiſhes, eſpecially after the Beſiegers have approached near the Creſt of the Glacis, becauſe their Lodgments are then liable to be ſeen, and plunged into by the Cannon of the Beſieged, and they find vaſt Difficulty in approaching and covering themſelves, on account of the intenſe Fire of Artillery and ſmall Arms, which fire then alſo with much more Certainty, and by reaſon of the Flights of Grenadoes and Stones, which can only be played with Succeſs when the Beſiegers are very near; but the principal and great Advantage attending cloſe and narrow Fronts, with Ramparts of a good Height, is ſeeing into the Lodgements of the Enemy, in Flank, that are eſtabliſhed on the Creſt of the Glacis, the Covered Way, and Outworks, and commanding wholly theſe Lodgements, as was evident in the Attacks of the Lunettes at the Siege of Bergenopzoome, and particularly when the Beſiegers attempted twice, but in vain, to lodge themſelves in the Drum of the Lunette Zealand, (w. Pl. 1.) altho' they had then nothing to fear from Countermines, the three Countermines of the Gorge of that Lunette having been blown when it was abandoned by the Beſieged. The Battery of the Enemy on the Creſt of the Glacis alſo fires at a much greater Diſadvantage againſt the Flank of the Baſtion, when the Diſtance is ſmall, and the Rampart of the Place high, becauſe the impelling Shot batters the Breaſt-work at a ſmaller Angle, and muſt therefore alſo be very unſucceſsful in diſmounting or ruining the Guns of the Flank, while this Battery of the Enemy is wholly ſubjected to its Command.

40. The Ravelin of the long Front is conſiderably larger than the Ravelin of the ſhort one; but that, I imagine, is a Diſadvantage to the former, becauſe it is too ſaliant, its Capital being 70 Toiſes (159), and therefore very badly commanded by the Body of the Place; and becauſe it will be more eaſily approached, eſpecially when the collateral Fronts are alſo long, the Defence which it derives, in that Caſe, from the collateral Ravelins, being inconſiderable (169); and Lodgements and Batteries may be eaſily thereon eſtabliſhed: Whereas the Ravelin of the ſhort Front of 160 Toiſes, is of a juſt Magnitude to command well the Field and collateral Outworks, and to be well commanded by the Body of the Place, and to allow of a good Redout or Retrenchment.

41. But the Gorge of the Ravelin, the re-entering Places of Arms, and the Counterſcarp of the great Ditch of the long Front, are more remote from the oblique Fire of the Curtain, and interior Extremities of the Flanks, than thoſe of the ſhort one: In the long Front alſo, the Faces of the Ravelin and the Faces of the Baſtions, are more remote from the ſaliant Angles of the covered Way and Glacis of each other, and the Faces of the re-entering Places of Arms do alſo re-

cede further from the ſaliant Angles of the covered Way and Glacis, than in the ſhort Front, which appear at once, on comparing the Figures 1ſt. and 2d. Hence there ariſes a very conſiderable Advantage in favour of the ſhort Front, in conſequence of the Reſiſtance to the Beſiegers in their Approaches to the Works thereof, being thereby greatly augmented (39); and conſequently the Length, Difficulty, and Fatality of the Attack. This Cloſeneſs of the Works of the ſhort Front will render Traverſes in its covered Way unneceſſary, leaving it more expoſed to the commanding Fire of the oppoſing Works (13); and the Ditch and Counterſcarp of its Ravelin will be much better commanded from the Face of the Baſtion, near its Shoulder; and the Defences of that Face of the Baſtion will be with more Difficulty ruined, or commanded from the oppoſite Counterſcarp before the ſaliant Angle of the Ravelin (39). From what is ſaid then, I think it is evident, that the Front of 160 Toiſes has hitherto the Advantage over the long one of 200 Toiſes; and ſo as to overballance in a conſiderable meaſure.

42. I know ſome are of Opinion that long Fronts are the ſtrongeſt, becauſe, ſay they, the Works of the Beſiegers muſt be proportionably more extenſive againſt the long than againſt the ſhort Fronts, and the Approaches more difficult to be executed; and becauſe the former will contain a greater Number of Cannon and Muſqueteers for their Defence. In order to try how far this Opinion is juſt, let us ſuppoſe two ſtraight Lines of equal Lengths, the one fortified with a Series of ſhort Fronts, and the other with long Fronts: Let us alſo ſuppoſe, that a Front of each Line is attacked by ſimilar Works; now it is evident that the Trenches of Approach in the Attack of the ſhort Front muſt

turn as often, and at as acute Angles, as in the Attack of the long Front; for the fortified Line of ſhort Fronts is as long as the Line of long ones; and if the Direction of the Branches of the Trenches fall ſooner without the ſhort Front attacked, they will light on the Works of the adjacent Fronts; ſo that the Trenches of Approach will amount to the ſame Quantity of Work in both, or nearly ſo; and if we allow the Paralels, or Places of Arms, to extend a little more to Right and Left, before the long Front, that will add very little to the Length of the Siege; the firſt and ſecond Paralels of the moſt extenſive Attacks being generally finiſhed in the End of the fifth or ſixth Day from breaking Ground; for it is not the Extent of the Works of the Beſiegers that lengthens a Siege, but the Reſiſtance they meet with in puſhing on theſe Works. But the Flanks of the Attack of the ſhort Front will be more annoyed, and commanded by the Works of the collateral Fronts, than the Attack of the long one by its collateral Fronts (41); which will oblige the Beſiegers to extend their Attack of the ſhort Front, till it comes to be at leaſt equal to that of the long one, and till they have embraced, almoſt wholly, the two collateral Fronts, by which the ſhort Front attacked is much more powerfully defended, than the long Front by its collateral Fronts; and if the former, and its collateral Fronts are very ſhort, the Flanks of the Attack of the Enemy will come to fall in with the Fire of the neareſt Works of the ſecond adjacent Fronts on each Side of the ſhort Front attacked; conſequently the Attack of the ſhort Front will come to be more extenſive, or at leaſt as much ſo, as that of the long one; beſides that the Enemy will be obliged to take the two collateral Ravelins of the ſhort Front attacked, when the Fronts are very narrow, and conſtructed on a ſtraight Line, or very open angled Polygon, which is demonſtrated in the Sequel (139, 169). The Baſtions of the long Front will contain, indeed, more Muſqueteers; but the Ricochet, which ſcours the Tops of the Breaſtworks of the Faces of the Baſtions, and the Fire of ſmall Arms from the Enemy's Lodgements on the Creſt of the Glacis render them of little Uſe in the Body of the Place, unleſs it be to defend the Retrenchments of the Baſtions; and in the low Flanks, the Breaches of their Faces, and the great Ditch: Beſides, in the narrow Fronts there is ſufficient Room for as many Muſqueteers as are neceſſary to fire againſt the Head of the Sap in the covered Way and Outworks, and into ſuch of the Lodgements as can be ſeen into; and they mount as many Cannon, in proportion to the Extent of the Counterſcarp, and Glacis, and Outworks that are under their Command, as the long ones, and generally, indeed, a great many more than the Beſieged have to ſpare.

43. In order to illuſtrate, ſtill further, the Advantage of ſhort Fronts over long ones, I ſhall ſuppoſe two Towns which will admit of regular Fortifications, the Radius of the Circumference of each of which is 200 Toiſes, to be fortified by ſimilar Works, ſuppoſe after the manner of Bergenopzoome, and the Length of the exterior Side of the Polygon of the one to be 200 Toiſes, and the other 150; conſequently the former will be a regular Hexagon, and the latter an Octagon; I ſhall ſuppoſe alſo, that each of them is regularly attacked by ſimilar Works: Now it is evident, that the Beſiegers will be obliged, in this Caſe, to extend the Flanks of their Attack of the ſmall Front, till it comes to be at leaſt equal to that of the large Front, not only from

the Motives abovementioned (42), but alſo becauſe the Angles of the Octagon, on which the ſhort Fronts are conſtructed, are more open than thoſe of the Hexagon, or becauſe any three Sides of the former Approach nearer to a right Line than any three Sides of the latter; and conſequently the former will have the Front attacked better defended by its collateral Fronts. The Trenches of the Beſiegers muſt, for the ſame reaſon, be cloſer, and turn at more acute Angles in the Attack of the Octagon, than againſt the Hexagon. Hence the difference of Strength will, in this caſe, be alſo conſiderable in favour of the ſhort Fronts; and as the Circumferences of both theſe Fortreſſes are equal, ſo the Gariſon that is neceſſary for the Defence of the Hexagon, during a Siege, will alſo be ſufficient for the Octagon of ſhorter Fronts and ſimilar Works; and be rather a ſtronger Gariſon to the latter, than to the former, becauſe the Outworks of the latter being ſmaller, and cloſer to one another and to the Body of the Place, and therefore more commanded by each other, and the Place, are maintained by ſmaller Guards; which was apparent in the Attack of the covered Way, and Lunettes, at the late Siege of Bergen-opzoome.

44. Perhaps it may be ſaid, that if the Demigorges and Capitals of the Lunettes of the long Front, and of the two next adjacent Lunettes of the collateral Fronts, are extended until their Faces approach as near the ſaliant Angles of the covered Way of the Baſtions and Ravelins, as thoſe of the ſhort Front; if ſo, I ſay, it may be ſaid, that the Approaches of the Enemy upon the produced Capitals of the Baſtions and Ravelin, will be as much commanded by theſe large Lunettes, as by thoſe of the ſmall Fronts: If the Lunettes then, of the long

Front, are ſo much enlarged, they will become too ſaliant, and be more eaſily approached, and leſs commanded by the Place and the Ravelin; and the Beſiegers will eaſily lodge and erect Batteries in them, which they cannot do in thoſe of the ſhort Fronts, but with the utmoſt Difficulty; and the Expence of ſuch a Series of long Fronts will then exceed that of the ſhort Fronts, excluſive of the other Advantages already mentioned in favour of theſe latter.

45. But if we ſuppoſe any Part of the Circumference of a Town to ſhoot out into a ſmall Front of 160 Toiſes, and that its collateral Fronts are long, *viz.* 200 Toiſes each, and to go off from the former at right Angles, ſo as that this ſhort Front ſhall be ſuſtained, almoſt wholly, by its proper Force; and compare it, in Point of Strength, with another Front of 200 Toiſes, whoſe Conſtruction, and collateral Fronts, and Angles of the Circumference are ſimilar to the former; in this Caſe, the Diſadvantages will be conſiderably leſs to the long Front than in thoſe we have already ſuppoſed, becauſe the Enemy will not only be obliged, in their Attack of the long Front, to extend further their Places of Arms, and their Lodgements on the Glacis and covered Way, but alſo to mount a greater Number of battering Cannon, becauſe they will have a larger Front to command, than in their Attack of the ſhort Front, which, in this Caſe, receives little or no Aſſiſtance from the Defences of its collateral Fronts, or no more than is derived to the long one from its collateral Fronts: The ſaliant Angles of the Glacis of the long Front will alſo be approached with a little more Difficulty than thoſe of the ſhort one. But the Advantages which ſpring from the powerful Command of the Outworks by the Place, and their cloſe and efficacious reciprocal Com-

mand of each other (3, 39, 41.) will ſtill overballance the Advantages ariſing, in this Caſe, in favour of the long Fronts; yet as theſe Advantages increaſe to the long Front, in reſpect of a ſhort one thus ſituated, as the ſhort one is diminiſhed, conſequently when the latter is contracted to a certain meaſure, probably to 140 Toiſes, it will come to be in Equilibrio with the long one of 200 Toiſes, in point of Strength; for the Diſadvantage reſulting from the Narrowneſs of a Front leſs than 160 Toiſes (47), increaſe, in a greater meaſure, in proportion to the Diminution thereof below 160 Toiſes, than the Advantages ariſing from the Increment of the Efficacy of its commanding Fire againſt the great Ditch and its Counterſcarp, the Outworks, and their Ditches and Counterſcarps, when ſuch a Front is ſituated as in the Caſe here ſuppoſed, or advanced ſingly in the Front of other Works, ſince the great reſiſting Force of a narrow Front depends, in a great meaſure, on the Defence it derives from its collateral Fronts (139, 169) and Ravelins; and if the ſhort Front is ſuppoſed ſtill leſs than 140 Toiſes, the Strength of the long Front of 200 Toiſes will then come to be ſuperior. The Caſe of advanced Hornworks, which have no collateral Works, is alſo analogous to the one here ſuppoſed: Therefore the nearer the Lengths of their Fronts approach to 160 Toiſes, the greater will be their Strength, and the contrary.

46. As very conſiderable Advantages are obtained by giving extenſive Faces to the Baſtions (64), and as the Flanks diminiſh as the Faces are extended, ſo the Perpendicular muſt be made as long as is conſiſtent with the other Conſiderations relative to the Defences of the Front. Defenſive Fronts of 160 Toiſes raiſed on the Sides of a Hexagon, will admit of a Perpendicular of 30 Toiſes, and of a

Face of 50 Toiſes for the Baſtion, which will give a Flank of 23 Toiſes 3 Feet: This, with the Addition of a Flank of the Gorge of 3 Toiſes, will be of ſufficient Extent to anſwer the Purpoſes for which it is intended (69, 70). The particular Length of 50 Toiſes which I aſſign to the Face of the Baſtion, after Count Pagan, ſeems alſo to be the beſt Proportion in a Front of 160 Toiſes, and of ſufficient Extent to contain enough of Cannon for the Defence and Command of the Outworks and the Field, after affording Space for as many Traverſes as are neceſſary to diſappoint wholly the Effect of the Ricochet; and to allow of a Ravelin whoſe Faces ſhall fall at three or four Toiſes above the Angles of the Shoulders of the Baſtions, with a Redout ſufficiently large, and directly flanked from the Shoulders of the Baſtions; and ſo as to allow alſo of Lunettes of the moſt juſt Magnitude, that ſhall be well flanked and commanded by the Ravelins and the Place, and that ſhall command well the covered Way, the Glacis and the Field.

47. But, if we ſuppoſe this Front (46) to be contracted to 140 Toiſes, the Flank, in conſequence of the Shortneſs of the Front, and of the Faces of the Demibaſtions being 50 Toiſes, will then come to be a great deal too little, even though we allow 30 Toiſes to the Perpendicular, and the Curtain will be too ſhort, eſpecially with a dry Ditch; and if the Perpendicular is made longer, the Baſtions will become leſs capacious, their ſaliant Angles much narrower, and the Curtain ſhorter, and more remote from the Gorge of the Ravelin, and the Gorges of the Lunettes; therefore a Front of 140 Toiſes will not bear to have above 44 Toiſes, at moſt, for the Length of the Face of the Demibaſtion, and the Ravelin will ſtill be too ſmall to admit of a good Re-

dout, its Faces produced inwards muſt fall on the Angles of the Shoulders of the oppoſite Demibaſtions, or very little higher; and the Lunettes will be either too ſmall, or badly flanked; and the Expence of a Series of ſuch ſmall Fronts is alſo greater than a Series of equal Extent of the former of 160 Toiſes.

48. Upon the whole then, I am of Opinion, that a ſmall Front of Fortification of 160 Toiſes, or nearly ſo, ſituate ſo as to be defended wholly by its proper Force, is ſtronger in Proportion to the Expence of it, either ſimply or with Outworks, than any other Front of a much greater or leſs Extent, that is ſituated and conſtructed after the ſame manner: And that a Series of Fronts, whether conſtructed on a ſtraight Line, or on the Circumference of a Polygon, at 160 Toiſes each Front, and with Ravelins and great Lunettes in the covered Way, has more abſolute Strength, and is alſo ſtronger, in Proportion to the Expence, than a Series of any other Fronts that are in any conſiderable Degree greater or leſs than 160 Toiſes, and conſtructed with ſimilar Works on a ſtraight Line, or Circumference of equal Extent. But it is demonſtrated in the Sequel (Chap. 14. Sect. 2.) That if the Fronts are to be conſtructed with Ravelins, or with Ravelins and Counterguards, and common Baſtions, on any Polygon above an Octagon, the beſt Length that can be aſſigned them will be about 140 Toiſes; which is to be extended in Polygons under an Enneagon, in a certain Meaſure, according as the Angle of the Polygon is leſs open; and about 150 Toiſes to ſingle unravelined Fronts, that are conſtructed on the Sides of any Polygon above an Octagon; which are alſo to be extended in a certain Proportion in ſmaller Polygons.

CHAP.

CHAP. II.

Concerning hollow Baſtions, and the Defence of ſolid ones by paliſadoed earthen Retrenchments; ſetting forth the Reaſons why the former are preferred to the latter, in the following Conſtructions.

49. IN each of the enſuing Methods of Fortifying, I make the Baſtions hollow; taking care, at the ſame Time, to leave a ſufficient Breadth of Rampart to allow of raiſing Traverſes parallel to the Faces and Flanks, to ſecure theſe againſt the Ricochet in reverſe; a Precaution of the utmoſt Importance; for wherever the Flank of a Baſtion happens to be plunged into in reverſe by the Ricochet, it muſt be thereby rendered inevitably uſeleſs, unleſs there is Room to raiſe a parallel Epaulment at the Extremity of its Platform: This broad Rampart alſo allows of more Room for repairing Breaſtworks that are very much damaged; the Baſtions, I ſay, of the following Methods, I have conſtructed hollow, not only to ſave Expence, but likewiſe becauſe the Expence of making them ſolid will never be compenſated by the Defence they generally make, or are capable of making, by Means of Retrenchments of Earth, nor nearly ſo. I am aware, that this Aſſertion will be at once condemned, at leaſt by thoſe who have never ſeen a Siege; after having read of the Defences of Candia and Vienna, againſt the Turks; and of the obſtinate Defences that have been made of Baſtions by Retrenchments in ſome other Places. I have therefore been led to give the following particular Account

of the Reaſons that have ſwayed me to this Opinion, that others may judge for themſelves.

50. Before the Uſe of the Ricochet was diſcovered by Mareſhal Vauban, and before the Biſhop of Munſter about the Year 1672, firſt began to make uſe of Bombs to good Purpoſe, by planting ſeveral Batteries of Mortars, and playing them inceſſantly into the Works attacked, the Beſiegers, after a Breach was made in an Outwork, or Baſtion, remained coolly and in good Order in the breached Work, to repel the Attack of the Enemy; there being nothing to give them any Diſturbance: For this Reaſon, the Breach was formerly much better defended, and alſo the Baſtion, by earthen Retrenchments, than they are now; and they may ſtill be well defended in any Siege where Bombs and the Ricochet, but eſpecially the former, are not uſed by the Enemy judiciouſly and in Profuſion, and the Beſieged are reſolute; which doubtleſs has been the Caſe at the Sieges of Candia and Vienna, by the Turks, and at Barcelona. But if a good and liberal Uſe is made of Bombs and the Ricochet, eſpecially the former, it will be impoſſible for ſufficient Guards to remain in the Baſtion attacked, without having every Night near a fourth of their Number killed and wounded; which was evident from the Effect of Shells every Night in the Baſtions attacked, in the late Siege of Bergenopzoome, beore the Enemy began battering in Breach, among the ſmall Guards of the Baſtions, which were then not above 24 Men in each Baſtion, and were intended chiefly to aſſiſt the Gunners. This Fire of Shells and the Ricochet, when the Baſtions come to be breached, and their Guards conſequently ſtrong, muſt be very fatal to theſe Guards, and occaſion the greateſt Confuſion amongſt them, and

give the Beſiegers an Opportunity of carrying, at once, the whole Baſtion, together with its Retrenchments, while the Guard of it, intent on their own Safety, neglect their Duty; ſome lying flat on the Ground to avoid the burſting of Shells, others skulking behind Traverſes, or under Carriages, to ſhun the Fire of the Cannon and Hobitz in ricochet, and the Flights of Grenadoes and Stones: Nor is it poſſible for the Officers to prevent this Confuſion, or keep the Men to their Duty, eſpecially in the Night.

51. Thoſe who are for defending Baſtions Inch by Inch, by paliſadoed earthen Retrenchments, will perhaps reply to this, That if the Guard of the Breach may, in Conſequence of this Confuſion, be eaſily repulſed by the Aſſailants, they will retire behind the Retrenchments, which being well paliſadoed, cannot be forced by the Enemy. The Guards of the Breach, unleſs they retire without making any Reſiſtance within the firſt Retrenchment, cannot afterwards, without giving alſo Acceſs to the Aſſailants, who are cloſe at their Heels. But waving this Particular, it is to be ſuppoſed, that the Ricochet and Bombs, the firſt the great Deſtroyer of Paliſadoes, and the laſt both of Paliſadoes and Breaſtworks, are kept playing, eſpecially for three or four Days before the Aſſault of the Baſtion, and till the Aſſault is almoſt begun, as frequent as poſſible into the Baſtions attacked, which muſt inevitably deſtroy ſome of the Paliſadoes of the Retrenchments, ſufficient to give Acceſs to the Beſiegers, who will meet with leſs Reſiſtance from the Guards of the Baſtions, by reaſon of the warm Fire of Artillery which immediately preceded the Aſſault. I am therefore of 'Opinion, that there is, at leaſt, an equal Chance in all Sieges, of the Baſtions and their Retrench-

ments falling together the firſt Aſſault after the Breaches are open, however brave the Defence may be, provided alſo the Attack is good, and that the Aſſailants puſh forward with Reſolution. The Beſieged therefore, if they have any Regard for their own Safety, and the good Event of their Cauſe, will apparently ſurrender without Delay, as Mr. Vauban has juſtly obſerved (53), that is, when the Paſſages or Epaulments of the great Ditch have reached the Baſtions, and before the Place is ſufficiently opened; for the precarious Chance of holding out two or three Days, within the Retrenchments, will rarely, if the Attack is judicious, and carried on in the Manner above ſuppoſed, be equivalent to the Detriment their Cauſe runs the greateſt Hazard of ſuſtaining, by having the Town ſtormed, and the whole Gariſon either cut to Pieces, or made Priſoners of War.

52. At Bergenopzoome the Baſtions attacked were retrenched, but I could never diſcover in what Manner theſe Retrenchments were capable of making ſuch a Defence as is generally aſcribed to Retrenchments of this Kind; ſome of the Paliſadoes were daily ruined, and the Breaſtworks of the Retrenchments ſhattered by Bombs as ſoon as repaired, and eaſily mounted wherever the Paliſadoes, by being broke down, gave Acceſs to them. Their Ditches, and ſome Part of the Terreplain of the Baſtion, at the Counterſcarps of theſe Ditches, were not ſeen by the Muſqueteers within the Retrenchments, by reaſon there was not Room to give them Flanks; and becauſe the Slope of the Creſts of their Breaſtworks was very ſmall, that their Aſcent might be rendered more difficult to the Enemy, and their Thickneſs conſiderable, to enable them to ſtand the Bombarding: Their Barriers were badly ſecured, and there was a Poſſibi-

lity of getting within the Retrenchments along the Creſts of the Breaſtworks of the Baſtions, the Ambrazures, which are generally made as narrow as poſſible in a Siege, being eaſily ſtept over.

53. The Gentlemen who are of Opinion, that a Baſtion is capable of making a long and obſtinate Defence by paliſadoed earthen Retrenchments, will advance, no doubt, in ſupport of it, that Marſhal Vauban, an Engineer of the greateſt Experience, and perhaps the moſt judicious that has hitherto appeared, has aſſerted the Poſſibility of ſuch a Defence of a retrenched Baſtion, and given a particular Detail of it in his Book of the Attack and Defence. That Marſhal Vauban was a very able Engineer, and of great Experience, is undeniable; and his Authority is therefore to be held in great Regard: But if I can make it appear, that the Manner of the Conſtruction of Marſhal Vauban's third Method, which he held in the higheſt Eſteem, favours my Opinion, I preſume my Authority will be, at leaſt, as good as theirs: Nor is there in this any Contradiction; for it will ſometimes happen that the Beſiegers ſhall not be provided with a ſufficient Quantity of Shells; and ſometimes the Attack may be languid and injudicious, and the Defence, on the contrary, conducted by able Engineers, and the Spirit of it, which is too apt to flag in the End of a long Siege, kept up to the laſt Day by an active, vigilant and brave Governor: In either of theſe Caſes, Mr. Vauban's Defence of a Baſtion may not be altogether impracticable; yet as theſe Circumſtances, ſo favourable for the Beſieged, will very ſeldom happen, Mr. Vauban has conſtructed the Baſtions of New Briſac ſo as not to be ſuſceptible of ſuch a Defence by means of Retrenchments, nor

has he himſelf, in Practice, had any Dependence on earthen Retrenchments; as will appear in the Sequel. In order to this, then, if we take a View of the Plan of New Briſac, we ſhall find, that Mr. Vauban has made the earthen Baſtions of the Place hollow, and conſequently not fit to make any tolerable Defence by Retrenchments; he has alſo cut off the Communication of the Tower Baſtion from the former, by a Retrenchment of Maſonry, which he knew well was the only one that was capable of putting a Stop, for a little Time, to the Aſſault of the Enemy. And that Mr. Vauban confided little in the Defence even of this Stone Retrenchment, is evident from his own Account of the Attack of the Tower Baſtion; which runs thus: The Paſſages of the great Ditch being properly executed, the Beſiegers will eaſily render themſelves Maſters of the Towers. The Place (which he ſuppoſes to have been already battered by the breaching Cannon on the Counterſcarp) will, nevertheleſs, not be as yet open; but ſince it may ſoon be ſo by means of a Mine, and as there is no Flank left unruined to the Beſieged, they will apparently beat the Chamade; ſince a more obſtinate Reſiſtance would only occaſion them to be made Priſoners of War. Nevertheleſs, if they ſtill hold out, the Beſiegers muſt lodge themſelves in the Ruins of the Towers made by the breaching Cannon, and break the Galleries to the Right and Left by Fougaſſes, or ſmall Mines; and afterwards come to puſh great Mines, whoſe Effect will not fail to open the Place; unleſs the Beſieged, careful of their Safety, do not prevent their total Ruin by an immediate Reddition: But as they will then be in a Condition to procure but very hard Terms, it is not to be doubted, he ſays, but they will ſurrender without Delay, eſpecially if the Beſiegers have taken good Care to throw plenty of Bombs and Stones behind and about the Tower Baſtions, during the Attacks of the Counterguards and Towers.

54. Mr. Vauban having obſerved, that the Baſtions of the Place can never make any tolerable Defence by paliſadoed earthen Retrenchments, if the Attack is good, for the Reaſons abovementioned (50, 51.); and becauſe they muſt be ſuſtained wholly by their proper Force, having no interior Work to flank and command them, was led to think of making large Counterguards with Flanks, or more properly detached Baſtions, from whoſe Defence, by Means of Retrenchments, he propoſed a great deal; and very well he might, becauſe theſe Retrenchments, or Traverſes of his detached Baſtion, are made perpendicular to the Faces of the flat and Tower Baſtions of the Place, from whence their exterior Sides are flanked, and the whole detached Baſtion commanded in the ſtrongeſt Manner; inſomuch that the Conqueſt thereof would be extremely difficult, altho' it had no Retrenchment at all, becauſe the Beſiegers muſt make themſelves Maſters of it by Sap, even after it is abandoned by the Beſieged, which will take up ſome Time, and meet with great Reſiſtance from the Artillery of the Place: So that the Caſe in an Outwork, and the Body of the Place in regard to Retrenchments, is wholly different; therefore we are not to ſuppoſe that Retrenchments are of good Defence in a Baſtion, becauſe they may be ſo in an Outwork. But the Reaſon is not ſo obvious why Mr. Vauban has made his detached Baſtions hollow, which therefore can never be capable of very good Retrenchments; the low Part of the Retrenchment being always liable to

be commanded from the Lodgement of the Enemy on the Terreplain of the Rampart, and the Breaſtwork of the Retrenchment on the Slope of the Rampart being eaſily ruined, and difficult to be repaired; for it is certain, that Mr. Vauban's detached Baſtions muſt make a much better Defence by the Help of Retrenchments, than without them; becauſe the Inſide of the Breaſtworks of their Faces is not flanked directly from any other Work, by which the Aggreſſors may, therefore, more eaſily puſh their Sap from the ſaliant Angle towards the Flanks, if there are no Retrenchments. The Sum, I imagine, to which he was limited, would not allow of making the flanking Counterguards ſolid, or he has been of Opinion that the Time gained by the Defence even of a ſolid detached Baſtion, by means of Retrenchments, above that in a hollow one, would not be equivalent to the Expence of making it ſolid, notwithſtanding the ſingular Advantages that would attend the Retrenchments in this particular Caſe.

55. Mr. Vauban has, indeed, made the Baſtions of his firſt Method ſolid, becauſe a very trivial Saving, only, could be gained by making them hollow, after leaving ſufficient Room for raiſing Traverſes againſt the Ricochet in reverſe; but as the Baſtions of the enſuing Methods are much larger, and their Gorges broader, by reaſon their Faces are longer, and their Flanks perpendicular to the Line of Defence, ſo there is not only a conſiderable Expence ſaved by leaving a great Part hollow, but alſo a ſufficient Breadth given to the Rampart of the Faces and Flanks. From what is ſaid then (49 to 55), I preſume it is evident, that Mr. Vauban entertained, at leaſt, ſome Diſ-

truſt of the mighty Defence of Baſtions by paliſadoed earthen Retrenchments; and that they are by no Means ſo much to be depended on as is generally imagined.

CHAP. III.

The ſhortening of Sieges of late Years, almoſt wholly occaſioned by the plentiful Uſe of Shells. The Attack, excluſive of the Ricochet, and the plentiful Uſe of Shells, not much improved ſince the Time of Frederick Henry Prince of Orange.

56. IT will not be foreign to our Purpoſe to obſerve here, that the ſhortening of Sieges of late Years, is almoſt wholly occaſioned by the plentiful Uſe of Shells; becauſe the particular Conſtruction of certain material Articles in the following Methods, is founded on this Conſideration. Bombs are of ſo much Importance in the Attack, and anſwer ſo effectually all the Ends which are obtained by Counterbatteries of Cannon, that there ſeems to be a Poſſibility of taking fortified Towns with Bombs only; and it is certain that there are always more of the Cannon of the Beſieged ruined and diſmounted by the Bombs, than by the Cannon of the Enemy, when the former are properly uſed and in Abundance. By means of Bombs, the Battery of Cannon which was erected in the dry Ditch of Tourney, in the laſt Siege of that Fortreſs, againſt the great Ditch and Breach of the Baſtion, and from which the Beſieged propoſed to themſelves great Effects, was wholly ruined. The concealed Gun immediately behind the Orillon, which ſome have mighty Dependence on, finds no Co-

ver behind the projecting Orillon from deſtructive Bombs. The Guards of the Works and the Gunners may ſhelter themſelves and the Cannon behind Traverſes, from the Effect of the Ricochet; but there is no where above Ground, any Security from Shells: They alſo deſtroy Paliſadoes, and moſt effectually Breaſtworks. By means of Shells, the Number of the killed and wounded of the Beſiged, comes now to be very little inferior to that of the Beſiegers, by reaſon that the Shells of the latter, will ſcarce ever miſs lighting in the Works attacked; but the Trenches and Lodgements of the Enemy are but ſmall Marks for the Shells of the Beſieged.

57. It may not be improper to obſerve alſo here, that, excluſive of the Ricochet, and the liberal Uſe of Shells, the Attack has received, ſcarce any other Improvement ſince the Time of Frederick Henry Prince of Orange; whoſe Attacks were carried on with as much Expedition, in proportion to the Reſiſtance, which was then greater for the Reaſons already mentioned (50), and in proportion to the Number of Workmen employed in the Trenches; and, at leaſt, with as much Vigour as now; and with as much Security from Sallies, which were never ſucceſsful againſt the Attacks of this great General, except once at Maeſtricht, occaſioned by Unalertneſs in the Guards of the Trenches; and ſeveral of his Approaches which were carried on with moſt obſtinate and undaunted Bravery, and indefatigable Labour, thro' Moraſs and Water; and along the Tops of Dykes and Cauſey's ſtrongly commanded, and well defended, are aſtoniſhing.

58. His Attacks, which conſiſted chiefly of Trenches of Approach, ſuſtained by Redouts and Demiplaces of

Arms, did not extend ſo far to Right and Left as they do now, becauſe the Guards of the Trenches were then ſcarce a Third of the Number which mounted in Mr. Vauban's time, and afterwards; and becauſe the Ricochet was not then known: For when Mr. Vauban diſcovered the Uſe of the Ricochet, he was under a Neceſſity of extending his Places of Arms, to ſuſtain the Ricochet Batteries, which ſcoured the Faces of the Demibaſtions attacked, and their intermediate Curtain, and the Faces of ſome of the collateral Works; and alſo to make more room for the Guard of the Trenches, which, in his time, began to be conſiderably ſtronger, by reaſon they brought then greater Armies into the Field, and the Gariſons of Places became proportionably more numerous: And when two Attacks were carried on at a ſmall Diſtance from each other, Prince Frederick Henry run Trenches of Communication from one Attack to the other, as in the Engliſh and French Attacks of the Forts St. Antoni and St. Iſabel, at the Siege of Boiſleduc; and which were the ſame as Mr. Vauban's Parallels, or Places of Arms.

59. The length of Prince Frederick Henry's Sieges were chiefly occaſioned by the vaſt Extent of his Lines of Circumvallation, which were ſometimes above 9 Miles in Circumference, and crowded with defenſive Works of every Kind; and by turning off Rivers into new Channels, and carrying his Lines thro' large Tracts of Moraſs and Inundation: And all this immenſe Work, beſides carrying on generally three Attacks againſt the Place, and affording Guards for theſe Lines to defend them againſt a ſuperior Army, he performed with a Force not exceeding 25000

Men, and ſometimes with a much leſs Number; which would appear in our Days almoſt incredible.

60. His Lines of Circumvallation were generally pretty well finiſhed before he began his Attacks; but there were, nevertheleſs, a conſiderable Number of Workmen employed during the whole Siege, in repairing or heightening the Breaſtworks of his Lines, and Works of Circumvallation; ſo that he could not afford to have many Hands employed in the Trenches: Yet, notwithſtanding of all theſe Diſadvantages (57, 59, 60), he reduced Breda in ſeven Weeks from the opening of the Trenches; and Boiſleduc in thirteen, excluſive of the time taken up in raiſing and perfecting the Lines of Circumvallation, and turning off the Rivers; and he carried on three Attacks againſt each of them. In the principal Attack of Boiſleduc, he took two ſtrong Forts, which had each a wet Fore Ditch; and then carried in his Approaches on a Cauſey 30 Paces broad, and about 250 Toiſes in length, which was traverſed and well defended, and well commanded by the Place and the Ravelin; and afterwards he reduced the Ravelin, which had alſo a wet Fore Ditch, and met with great Reſiſtance in paſſing the great Ditch of the Place. In Prince Frederick Henry's Attack of Hulſt, they firſt began to paſs the great wet Ditch without making any Gallery of Carpentry; there the great Moat was filled up in one Night, and paſſed without any Gallery.

CHAP.

CHAP. IV.

Remarks on Mr. Vauban's Rules for determining the Lengths of the Perpendicular and Faces of the Baſtions, in Squares, Pentagons, and all other Polygons, and in Fronts of different Lengths. To which is ſubjoined, a Table of Count Pagan's Proportions of theſe in Squares, and all other Polygons; in Fronts of 160, 180 *and* 200 *Toiſes: Together with a comparative View of both, exhibiting the Principles on which they are founded, and the Meaſure of their reſpective Advantages.*

61. MOST Authors of new Syſtems of Fortification, differ in the Lengths they have aſſigned to the Perpendicular and Face of the Baſtion, in Squares, Pentagons, and all other Polygons: The Proportions which ſome Authors have given of theſe, are confined wholly to particular Syſtems, thoſe of ſome others may be more generally applied. The following ones, which are ſaid to be Mr. Vauban's, are regarded by many as the beſt, and of moſt general Uſe; *viz.* That in all Squares the Perpendicular ſhall be $\frac{1}{8}$ of the exterior Side; in Pentagons $\frac{1}{7}$; and in all other Polygons $\frac{1}{6}$, provided alſo that the Face of the Baſtion be $\frac{2}{7}$ of the exterior Side; and the Length and Poſition of the Flank is found by deſcribing an Arch from the interior Extremity of the Face of the Baſtion inwards, till it is terminated by the Production of the Line of Defence, from the inward Extremity of the oppoſite Face as Centre, its Chord forming Mr. Vauban's ſtreight Flank. Theſe Rules of Mr. Vauban's for finding the Length of the Per-

pendicular and Face of the Baſtion, and the Length and Poſition of the Flank in Polygons of every Kind, and Fronts of different Lengths, are indeed ingenious; and notwithſtanding they are ſo general, yet they happen in ſome certain Polygons, and ſome Sides of particular Lengths, pretty nearly to anſwer almoſt all the various Conſiderations which determine the beſt Proportions of the ſeveral Members of ſimple defenſive Fronts: They will approach pretty near to Truth in Squares and Pentagons (67), but will be more remote from it in all other Polygons: The Face of his Baſtion will always be too ſhort for the ſtrongeſt Fronts (64, to 67, 70, 149.); and his Perpendicular will be too long in Fronts of great Extent (63, 66), and rather too ſhort in narrow and very open angled ones (70). If a Circumference of 390 Toiſes Radius, is required to be fortified with an Enceinte of the ſtrongeſt ravelined Fronts which it is ſuſceptible of, the exterior Side muſt have about 140 Toiſes only in length, and the Fronts muſt be conſtructed according to the eighth Method (136 to 142), which has the Face of the Baſtion, the Perpendicular, and the Demigorge of the Ravelin longer, in proportion to the Length of the exterior Side, than thoſe of Mr. Vauban's firſt defenſive Conſtruction. An Enceinte of the ſame Diameter of Mr. Vauban's ravelined Fronts, will therefore be leſs expenſive than the former; but the former will have more abſolute Strength, and be alſo ſtronger in proportion to its Expence, than Mr. Vauban's (41, 49).

62. Count Pagan's proportions of the Lengths of the Perpendicular and Faces of the Baſtions, in Squares and all other Polygons, except Pentagons, with Sides of 160, 180, or 200 Toiſes; and the Poſition of his Flank, appear to

me to be extremely judicious: I have therefore thought it proper to inſert them here, and to compare them with Mr. Vauban's; which will give us ſome light into the Principles upon which they are founded.

	The great Fortification.		The Mean.		The Little.	
	For Squares.	For all other Polygons.	For Squares.	For all other Polygons.	For Squares.	For all other Polygons.
Exterior Side.	200 Toiſes.	200 Toiſes.	180 Toiſes.	180 Toiſes.	160 Toiſes.	160 Toiſes.
Perpendicular.	27	30	24	30	21	30
Face.	60	60	55	55 .	45	50
Flank.	22	24 To. 2 Feet.	19 To. 1 Foot.	24	18 To. 3 Feet.	23 To. 2 Feet.
Courtin.	73 To. 2 Feet.	70 To. 5 Feet.	63 To. 4 Feet.	60 To. 4 Feet.	63 To. 5 Feet.	50 To. 4 Feet.
Line of Defence.	141 To. 4 Feet.	141 To. 2 Feet.	126 To. 1 Foot.	126 To. 5 Feet.	115 To. 5 Feet.	112 To. 3 Feet.

In defenſive Fronts that are leſs than 180 Toiſes, nor inferior to 160, and are conſtructed on the Sides of any Polygon above a Pentagon, Count Pagan's Perpendicular will be longer than Mr. Vauban's; but as the Face of his Baſtion is alſo longer, the Length of the Flank thereof will not exceed Mr. Vauban's. The flanked Angle of Mr. Vauban's Baſtion will be more open than that of Count Pagan's; becauſe his Perpendicular is ſhorter, and the Advantages from thence ariſing will attend it in a Meaſure adequate to its Aperture (63); but Count Pagan's will have Advantages above the other, which ſpring from an extenſive Face of the Baſtion (64), in a meaſure adequate to the Exceſs of its Length, above that of Mr. Vauban's. Before we can determine to which Side to give the Preference, we muſt firſt ſee what theſe Advantages are, and in what Meaſure they take place in each of the preceding Methods of determining the Proportions of the ſeveral Members of ſimple defenſive Fronts.

63. When the ſaliant Angles of the Baſtions of any particular Front of an Enceinte, are very narrow, 1ſt. They intercept the Fire of the collateral Works, and derive thence little or no Aſſiſtance. 2dly, The outward Angle of the Counterſcarp is alſo proportionably acute, and but a ſmall Portion of the Counterſcarp of the collateral Front is ſeen from the Flank of the Baſtion (38). 3dly, The covered Way becomes very ſaliant, and its Branches or Faces, and thoſe of the Glacis of Courſe very long, which will occaſion their ſaliant Angles to be more remote from, and leſs commanded by, the interior and collateral Works (41.), and to be eaſily approached by the Beſiegers; and they intercept and prevent in a great Degree the reciprocal Defence of the Ravelins of each other. 4thly, The Baſtion becomes narrow and confined, and if two Guns are planted pretty cloſe to its ſaliant Angle, the Gunners will not have ſufficient Room to ſerve and traverſe them. 5thly, The Corner of the Wall of the flanked Angle by being too ſharp, will be eaſily ruined by the Enemy's Cannon; then give the Miner an Opportunity of attaching himſelf unſeen from either Flank. 6thly and laſtly, The Front of the Enemy's Attack will be of ſmall Extent, ſince the Baſtions and their covered Way may be ſcoured from Batteries in Ricochet that are erected at a ſmall Diſtance to the Right and Left of the produced Capitals of the former, and the Ricochet Batteries will therefore be leſs expoſed to the Fire of the collateral Fronts. In Baſtions whoſe ſaliant Angles are very open, the contrary of all theſe will take place.

64. The Advantages that ariſe in conſequence of giving extenſive Faces to the Baſtions, are, that they contain a

great deal of Fire for flanking and defending the Outworks and the Field, after affording ſufficient Space for raiſing Traverſes on, to intercept the Bullets and Shells of the Cannon and Hobitz that are fired in Ricochet; the Baſtions are alſo thereby rendred more ſpacious, and their Gorges broader, and the Line of Defence is ſhortned in Proportion as the Face is extended; the Flanks indeed become ſhorter, which occaſions Count Pagan to give his ſmall Fronts a pretty long Perpendicular, which again is productive, in ſome meaſure, of the Diſadvantages above mentioned (63), ſince the Angle of the Baſtion becomes leſs in Proportion as the Perpendicular is entended. When the Faces are very ſhort, the contrary of theſe take Place.

65. In Fronts of 160 Toiſes conſtructed on the Sides of a Hexagon, the Length of Count Pagan's Flank comes to be equal to that of Mr. Vauban's; the Face of the Baſtion of the former is 50 Toiſes, Mr. Vauban's only 46; Count Pagan's Line of Defence is 112 Toiſes 3 Feet, Mr. Vauban's 118 Toiſes 3 Feet. The Angle of Mr Vauban's Baſtion is 83 Degrees, and Count Pagan's 78 Degrees 30 Minutes. Mr. Vauban's Baſtion then has the ſaliant Angle opener by 4 Degrees 30 Minutes, than Count Pagan's, and it is a little leſs expenſive. Count Pagan again, to ballance theſe Advantages, has the Face of his Baſtion longer by 4 Toiſes, and his Line of Defence ſhorter by 6, than thoſe of Mr. Vauban; his Baſtion is alſo more ſpacious, and the Angle of the Shoulder opener and more capacious, beſides other Advantages which attend the Poſition of his Flank, which are ſpecified in the Sequel (71). The Diſadvantages of a narrow angled Baſtion are doubtleſs very great (63); but it is obvious, that thoſe ariſing to Count Pagan's, in conſe-

quence of its being 4 Degrees 30 Minutes leſs open than Mr. Vauban's, will be inconſiderable (38). Upon the whole then, I am of Opinion, that the Preference inclines rather to Count Pagan's Hexagon, notwithſtanding Mr. Vauban's is leſs expenſive.

66. In Fronts above 180 Toiſes, Mr. Vauban's Perpendicular will be longer than Count Pagan's, and the Face of his Baſtion will be ſhorter, conſequently the Flank of his Baſtion will be conſiderably longer: But the Flank of Count Pagan's Baſtion being 24 Toiſes long, will contain eight Pieces of Cannon, which therefore amounts to a ſufficient Length (69), eſpecially if the great Ditch at the ſaliant Angle doth not exceed 18 Toiſes: In this Caſe then his Front will have Advantages above Mr. Vauban's, in Proportion as the Angle of his Baſtion is opener, and the Face of it longer (63, 64); beſides the Advantages which reſult to Count Pagan's from the Poſition of his Flank (71). Mr. Vauban's will indeed have the Advantages which ſpring from a long Flank, which however ſeem to be fully balanced by ſome of the Diſadvantages which are peculiar to a long Front being thereby increaſed; ſince it occaſions the Ditch of the Curtain to be wider, and the Ravelin and inward Places of Arms conſequently to recede further from, and be leſs commanded by the Curtain, and interior Extremities of the Flanks: The Aſcendant then will be conſiderable in favour of Count Pagan's Proportions of the Perpendicular and Face of the Baſtion, in Polygons above a Pentagon, whoſe exterior Sides meaſure above 180 Toiſes each.

67. Count Pagan has been of Opinion, that a Flank of 24 Toiſes was of a ſufficient length for any defenſive Front; and therefore he always gives 30 Toiſes to the Perpendicular,

where the Angles of the exterior Sides will bear it, extending very judiciouſly the Face of the Baſtion with the Front, ſo as to give 24 Toiſes of a Flank, or very little leſs or more in any Front between 160 and 200 Toiſes; by that means gaining conſiderable Advantages (64, 66), which would have been, in a great meaſure, loſt, had he extended his Flank to a much greater Length by ſhortning the Faces. I cannot, however, I muſt own, agree with Count Pagan in aſſigning 30 Toiſes to the Perpendicular in Pentagons; which will occaſion the Angle of the Baſtion to be a great deal too acute, eſpecially in narrow Fronts; and I am of Opinion that Mr. Vauban's Rule for finding the Perpendicular to Fronts of different Lengths in Pentagons, approaches much nearer to Perfection.

CHAP. V.

A general Narrative of the Conſtructions of ſome few things in the ſubſequent Methods of Fortification, that are moſt eſſential to theſe Methods, and common to all or moſt of them; with particular Accounts of the Advantages they yield.

68. As I judge it tedious, and in ſome degree ſuperfluous, to give particular Narratives of the lineal Conſtructions of the ſeveral defenſive Pieces of each of the ſubſequent Methods of Fortification; ſince any one who is but a little accuſtomed to Plan-drawing, will never be at a loſs to conſtruct them, if he has the Specimen before him, and the Length of the exterior Side given; ſo I ſhall only give the following general Narrative of the Conſtructions of

a few things that are moſt material and eſſential to theſe Methods, and common to all or moſt of them, with the Reaſons and Principles on which they are founded.

69. The Flank of the Baſtion is doubtleſs a very eſſential Member of a defenſive Front, and therefore ought in all Conſtructions to have as great a Length as is conſiſtent with the Uſe of it, and that of the other Members of the Front: But there is no Author whom I know, who has yet aſcertained, by clear and undoubted Facts in Practice, the beſt Proportion for the Length of the Perpendicular with reſpect to the Length of the Front, and the Meaſure of the Angle of the Circumference. The defending Power of the Flank of the Baſtion ſeems to me to have been magnified by moſt Authors of defenſive Conſtructions, while the Defences which flank and command the Faces and Ramparts of the Out-works, the covered Way, and Creſt of the Glacis, have been too little attended to; notwithſtanding it will be generally found that the Length and Fatality of the Attack is chiefly owing to the Defence of theſe Out-works by the Fronts which flank and command them, when the Defence is tolerably well conducted; and that the Paſſage of the great Ditch is always eaſily accompliſhed when the Beſiegers are well ſtored with Mortars and Bombs, and make a good Uſe of them; and the greater the Number of Cannon that are planted together in the Flanks of the Baſtions attacked, the more of them proportionably will be deſtroyed by the Bombs, as well as by the Counterbatteries of the Enemy; ſo that it will very rarely happen that the Beſieged ſhall be provided ſo abundantly with Cannon in the End of the Siege, as to keep two Flanks of 24 Toiſes each, conſtantly full of great Guns, after the Aggreſſors have opened their Batteries againſt them,

ſince there will be a Neceſſity for a continual Supply of ſufficient Guns in the room of thoſe that ſhall be almoſt every Hour diſabled, and diſmounted by the Effect of the Counterfire of the Enemy's Cannon and Mortars; ſo that the Beſieged may, in this manner, expend in a little time, as many Cannon as might be ſufficient for the Defence of the Fortreſs during the whole Siege. Therefore the Beſieged cannot afford to plant above four or five Pieces of Cannon together in the Flank of a Baſtion, for the Defence of the great Ditch and Breach of the Baſtion; conſequently a Flank of 16 Toiſes with the Addition of a Flank of the Gorge of four or five, will be a ſufficient Length for the Baſtions of any Front whatſoever; if ſo, a very conſiderable Improvement may be made in all defenſive Conſtructions by giving a greater Extent to the Faces of the Baſtions (64, 67); and alſo by ſhortening the Perpendicular, and conſequently enlarging the flanked Angles of the Baſtions, and diminiſhing the Breadth of the Ditch of the Curtain, and obtaining the important Advantages which do thence ariſe (63, 39).

70. That this Diminution of the Flank of the Baſtion would be an Improvement of ſome Conſequence, I muſt confeſs ſeems to me, at preſent, evident both from Reaſon and Practice. Nevertheleſs, leſt my Authority, from the little Experience I have had, ſhould not be deemed ſufficient to enforce this new Hypotheſis, ſo contrary to the Opinion of ſome able and experienced Engineers, I ſhall in the mean time conform with the common received Opinion with Regard to the Flank of the Baſtion; and ſhall give 30 Toiſes to the Perpendicular of a Front of 160 Toiſes, in a Hexagon, and every other higher Polygon, after the manner of Count Pagan, more eſpecially ſince I have found that the

principal Diſadvantage which reſults from ſo great a Length of the Perpendicular, in Conſequence of its rendering the Angle of the Baſtion leſs open (Articles 2, 3, of Par. 63.), may be avoided in ravelined or more complex Fronts, by cauſing the Branches of the Counterſcarp of the great Ditch to diverge outwards three or four Toiſes, at the inward Angles; which will alſo be productive of other eſſential Advantages that are ſpecified in the Sequel (74), and without incurring any material Diſadvantage. I give 50 Toiſes to the Face of the Baſtion of a Front of 160 Toiſes conſtructed on a Hexagon, or higher Polygon, which is to be extended with the Front, according to the Proportion aſſigned thereto by Count Pagan, with reſpect to the Length of the exterior Side. A Perpendicular from 27 to 30 Toiſes incluſive, may be given to Fronts betwixt 139 Toiſes and 160, on the Sides of any Polygon above an Octagon; and from 42 Toiſes to 50 to the Face of the Baſtion; the Perpendicular being in this Caſe to be made longer or ſhorter, according as the Angle of the Circumference is more or leſs open and the exterior Side of a greater or leſs Extent, but ſo as not to exceed 30 Toiſes; and the Length of the Face is to be determined chiefly by the Length of the exterior Side. In Polygons under an Enneagon, Squares included, whoſe exterior Sides are of any Length betwixt 144 and 160 Toiſes incluſive (142), the ſhorteſt Perpendicular will not be inferior to 18 Toiſes, nor will the longeſt exceed 30, and the Length of the Face of the Baſtion will be found betwixt 43 and 50 Toiſes incluſive; both the one and the other in theſe, as well as in the former Polygons, muſt be determined by the Meaſure of the Angle of the Circumference, and the Length of the exterior Side, according to the Principles already exhibited (62 to 67, 70). In Fronts of 150 Toiſes conſtructed on the Sides of a Hexagon, 26 Toiſes will be ſufficient for the Length of the Perpendicular, and 48 for the Face of the Baſtion; and in Fronts of 160 Toiſes that are conſtructed on the Sides of a Pentagon, it will not be proper to give more than 24 Toiſes to the Perpendicular, and 49 to the Face of the Baſtion. Theſe Flanks I ſtill enlarge by the Addition of a Flank of the Gorge from three to five Toiſes, after the manner of Mr. Coehorn (4); becauſe this ſupplemental Portion is productive of great Advantages, is attended with little or no Expence, nor induces any obſervable Diſadvantage. Then I flatter myſelf the Flanks of our Methods will be intirely agreeable to all thoſe who have a mighty Opinion of an extenſive Flank; and the rather becauſe this conſiderable Length of Flank is attained without incurring ſome of the greateſt Diſadvantages which the ſame Length of a Flank would have induced, were it conſtructed wholly together with the other Members of the Front, according to Count Pagan's or Mr. Vauban's Rules, (61, 62). I have, nevertheleſs, had due Regard to the more important Defences which flank and command the Outworks, the covered Way, and Creſt of the Glacis, by giving a good Length to the Face of the Baſtion, and by means of other remarkable Conſtructions, as will appear in the Sequel.

71. I make the ſtraight Flank of the Baſtion, in each of the following Methods, perpendicular to the Line of Defence, after the manner of Count Pagan; becauſe in that Poſition it flanks the Face of the oppoſite Baſtion, and the great Ditch, in the moſt direct manner, and enlarges the Gorge of the Baſtion, and ſhortens, in ſome meaſure, the Line of Defence; its interior Extremity alſo bears at a larger

Angle againſt the Battery of the Enemy on the Counterſcarp, before the ſaid Face of the Baſtion, than if the Angle of the Flank were leſs open; and the convex Portion, BX, Pl. III, next the Shoulder of the Baſtion, flanks more directly the Ditch of the Redout (E) of the Ravelin. No Diſadvantage can attend this Poſition of the Flank, becauſe the Enemy can never ruin the Defences of the Flank of a Baſtion, or diſmount its Cannon directly, and much leſs obliquely from the Field (31), even though there are no Lunettes; the Curtain, 'tis true, is thereby rendred ſhorter, which, however, is rather an Advantage, provided the Baſtions have low Flanks when the Ditch is dry, or when the Front is very narrow: When the Flank makes an acute Angle with the Line of Defence the contrary of all theſe take Place. The interior Extremity A, of the ſtraight Flank, is produced three Toiſes within the Line of Defence (I,), ſo as to give a Flank of the Gorge, after the manner of Mr. Coehorn (4); and the Retreat (AC) of the Curtain is directed in a right Line to the Vertex (B) of the Angle of the Shoulder of the Baſtion.

72. The Concave and convex Portions of the Flanks are Arches of 60 Deg. each of which has for its Chord the half of the ſtraight Flank. The Portion next the Shoulder is made convex, becauſe in that Form it defends more directly the Ditch of the Redout of the Ravelin, and leaves more room at the Shoulder of the Baſtion; and alſo commands better the ſaid Redout: The interior Portion is concave, becauſe its interior Extremity bears more directly againſt the Battery of the Enemy on the covered Way, before the Face of the oppoſite Demibaſtion; theſe interior concave Portions have alſo a good Effect in narrow Fronts, by lengthening, in ſome meaſure, the Curtain, and conſequently expoſing

more effectually the Ditch thereof to the Fire of the Flanks: They alſo leave a large Space within the Breaſtworks of the low convex Flanks (H); and both the convex and concave Portions of the high Flanks do anſwer better theſe Purpoſes, and are leſs liable to be enfiladed by the Ricochet, than if they were Segments of a greater Circle.

73. I give 15 Toiſes only to the Breadth of the great Ditch at the ſaliant Angle, whether it has Water or not; becauſe greater Advantages in general do ariſe from pinching the Beſiegers in Ground, for raiſing their Batteries on the Counterſcarp, than in giving them a good deal, and making the Fronts of the Place, which oppoſe it, proportionably greater: Becauſe it will often happen, in the End of a Siege, that tho' the Beſieged have a much greater Front to oppoſe to the Battery of the Enemy on the Counterſcarp, yet they will not have a Number of Cannon left undiſabled, ſufficient to command that Battery: However, it is better to have, at the ſame Time, a Front as much ſuperior to that of the Enemy on the Counterſcarp, as is poſſible, and conſiſtent with the other Conſiderations regarding the Defences of the whole; and which I have chiefly aimed at in the following Methods: For the Beſiegers will always, if the Defence is good, be under a Neceſſity of mounting Counterbatteries on the Creſt of the Glacis, as they will very ſeldom or never, have a ſufficient Number of Bombs to anſwer wholly the End of ſuch Batteries; and the Expence of ſo great a Quantity of them would be immenſe.

74. In the following Methods I make the interior Line of the Demigorge (Q, Pl. III.) of the Redout of the Ravelin, in a right Line with the Angle (B) of the Shoulder

of the Baſtion, and the ſaliant Angle (w) of the Counterſcarp of the great Ditch; and the Faces, or Branches of the Counterſcarp (K, W.) are made to diverge, or recede outwards from the Faces of the Baſtions, towards the reentring Angles, ſo as to cut, if produced, the Flanks of the Redout at 3 or 4 Toiſes (F) above their interior Extremities; and the Extremities of the Faces of the Ravelin (D), are terminated by this diverging Counterſcarp produced. From this particular Conſtruction do ariſe the following Advantages: The Face of the Baſtion is ſeen in reverſe from the whole Flank of the Redout, and from about an Half of it, the whole Ditch of that Face is ſeen in Flank; which will prevent the Beſiegers from beginning to the Paſſage of the great Ditch, until they are Maſters of the Redout of the Ravelin, which will occaſion them to loſe a conſiderable Number of Men in their Lodgements in the Ravelin and its Redout, even after they are Maſters of them, becauſe they are ſo much commanded by the Body of the Place; and that they muſt be ſome Time in Poſſeſſion of them before the Place falls. The Flank of the Redout alſo bears againſt a great Part of the Ditch and Counterſcarp of the remote Face of the oppoſite Baſtion, and againſt more or leſs of it, according as the Angle of that Baſtion is more or leſs open; and it cannot be commanded from the Ravelin, becauſe it is ſo much retired within the Line of the Counterſcarp, and is covered in ſome meaſure by a ſmall Orillon: A Traverſe may be raiſed on the Breaſtwork and Rampart of the Redout, at the Orillon, that the Terreplain of the Rampart of its Flank may not, on account of its Loweſs (88), in reſpect of the Ravelin, be liable to be commanded from the Breaſtwork of that Piece.

The Counterſcarp, by reaſon it diverges towards the re-entring Angle, comes alſo to be much more directly ex-poſed, and conſequently the Enemy's Batteries thereon, to the oblique Fire of the Curtain, and of the interior Ex-tremities of the Flanks of the Baſtions.

75. In the following Methods with Lunettes, I make the Face of the Ravelin produced to cut the Face of the Baſtion at three or four Toiſes from the Angle of the Shoulder, and in ſome particular Conſtruction at ten Toiſes, as in the eighth Method, which is a very conſiderable Advantage, becauſe the Redout comes thereby to have its Ditch better flanked, and the Beſieged have room to ſerve, at the ſame time, the Cannon which command the great Ditch and the Ditch of the Ravelin, and the oppoſite Counterſcarps; and the Inſide of the Breaſtwork of the Face of the Ravelin may be flanked directly from the Shoulder of the Baſtion, which is alſo of the utmoſt Conſequence, becauſe the Sap of the Enemy that is carried forwards along the Footbank of the Faces of the Ravelin will be ſeen into, and wholly commanded from the Shoulders of the Baſtions, on Account of their Proximity and ſuperior Height: Cavaliers in the Baſtions would command ſtill more powerfully theſe Saps of the Enemy; but the Advantages attending them, though very conſiderable, will ſcarce be equivalent to the Expence attending their Conſtruction, and of making full Baſtions to ſuſtain them: So that our Ravelin has all the Advantages of the common flanked Ravelin, and in a much greater degree, in conſequence of the ſpacious inward projecting Flanks of its Redout, and alſo the Advantages of the common Ravelin, without Flanks; and with-

out incurring any of the Diſadvantages peculiar to the former.

76. In all theſe Methods I would chuſe to give the Wall of the Rampart a Slope equal to $\frac{1}{3}$ of the perpendicular Height, by which means a great deal will be ſaved, by making the Wall thinner, and without Counterforts, or with ſmall ones only. I would give the Wall of the Rampart of the Place, the Ravelins, Counterguards, and detached Baſtions, 4 Feet at Top, to which by adding one Foot to every five Feet of perpendicular Height, the Thickneſs of the Wall at the Bottom of the Ditch is found. For Example, If the Wall of the Rampart is 15 Feet high, the Thickneſs at Top being 4 Feet, that at Bottom will conſequently be 7; and in the ſame Proportion in all other Heights. To the Wall of Counterſcarps I give only 3 Feet at Top; conſequently where the Wall of the Counterſcarp is 15 Feet high, its Thickneſs at Bottom will be 6 Feet, which, aided by ſmall Counterforts, when the Earth is ſandy, will be ſufficient, I imagine, to reſiſt the lateral and oblique Preſſure of the Earth of the Rampart. But as the Revetement or Wall of Maſonry is not equally reinforced in its whole Extent by Counterforts, it will be better, I imagine, to ſubſtitute in their Room, one, two, or more Rows of large thin flat Stones, in this manner: One Extremity of each Stone muſt be inlaid one Foot in the Body of the Wall, while the other Extremity projects about 3 Feet into the earthen Rampart, each Stone being ſuppoſed 4 Feet in Length: Theſe Stones may be about 5 Inches thick, all except 5 or 6 Inches of their Extremities which are lodged in the Body of the Rampart, which muſt be about 9 Inches thick, to take ſome hold of the

Earth, and reinforce more effectually the Wall againſt the lateral and oblique Preſſure of the incumbent Rampart: The whole Row and each Stone thereof, muſt be placed in the ſame Parallel with reſpect to the Horizon. When the Revetement is 30 Feet high, if there are two Rows, the firſt may be 11 Feet from the Foot of the Revetement, and the ſecond 21; if there are three Rows, the firſt may be at 9 Feet from the Foot of the Wall, the ſecond at 16, and the third at 23. In the interior Extremity of each of theſe binding Stones, there may be two, three, or more Holes, thro' which Pickets of Oak may be drove, to counteract ſtill more the Preſſure of the earthen Rampart againſt the Revetement. Theſe, in my Opinion, will anſwer the Purpoſe far better than Counterforts; and they are much leſs expenſive.

77. All the Diſadvantages which attend this Method (76) of eaſy ſloping Revetements that I can ſee, are, that the Ditches of theſe Works will be rendered ſomewhat narrower at Bottom, and one Cannon at the Angle of the Flank cannot be brought to bear againſt the Foot of the Wall of the Face of the Baſtion. This latter Inconvenience is quite trivial; and alſo the former in large Ditches, as thoſe of the Works abovementioned. And in narrow Ditches, as thoſe of Redouts in the Gorges of large Works, it may be made in the common Way, with the Slope at $\frac{1}{5}$ or $\frac{1}{6}$ of the perpendicular Height, and the Thickneſs greater in Proportion. This ſloping Wall will as effectually prevent Surprizes as a perpendicular one; and as certainly oblige the Enemy to batter it in Breach from the Counterſcarp; and it will be more difficult to make an open Breach

therein

therein by Cannon, by reaſon of the great Slope (19): And as it is leſs expenſive, I carry it up within 8 Feet of the Top of the Breaſtwork of the Face of the Baſtion, and give only one Foot, or one Foot and an Half at moſt, to the Berm; which is alſo a conſiderable Advantage: I carry it up alſo to the ſame Diſtance from the Top of the Breaſtwork, in Ravelins, Counterguards and detached Baſtions; but in the Curtain, to the Height of five Feet only above the Surface of the Field.

78. The Heights of the Rampart of the Body of the Place that are propoſed in the following Methods, are 18, 19, 20, and 21 Feet, from the Level of the Field to the Creſt of the Breaſtwork; becauſe the Advantages ariſing from a high Rampart (39), by its great Command of the Outworks, and bearing in Flank into the Lodgements of the Enemy which are eſtabliſhed therein, will overballance greatly the Diſadvantage it incurs by being more expoſed to the Field Batteries of the Aggreſſors, than a Rampart of a leſs Height; ſince the Damage the former ſuſtains by the Fire of theſe Batteries may be repaired at all Times of the Siege (28): A low Rampart is alſo liable to be ſcoured more ſucceſsfully by the Ricochet than a high one.

CHAP.

C H A P. VI.

Imperfections attending the Works of Bergenopzoome, which were manifeſted in the Courſe of the late Siege; the Cauſes from whence they proceed, and how they are to be remedied.

79. NOtwithſtanding Mr. Coehorn's Method of Bergenopzoome is, in all Probability, the ſtrongeſt of any that has hitherto appeared, in Proportion to its Expence and Degree of Simplicity; yet it is not wholly faultleſs. Nor is it to be expected that any particular Method of Fortification can be at once brought to Perfection; it may ſtill retain ſome Blemiſhes which may eſcape the Notice of the moſt diſcerning Engineer, and which nothing but an Attack of it well conducted can diſcover. There are alſo ſome Defects which the Constructer may be conſcious of, but cannot avoid, without incurring greater, or becauſe he cannot exceed a certain Expence to which he is reſtricted; and which I imagine has been, in a great Degree, Mr. Coehorn's Caſe, with regard to the few Imperfections of the Works of Bergenopzoome, which appeared in the late Siege of that Fortreſs; and whereof it may not be improper to give the following Account, before we proceed to the firſt of the enſuing Methods, which takes, in a great meaſure, its Riſe from that of Bergenopzoome.

80. It appears from what is ſaid in the firſt Section, (11, 25) that if the French had been obliged to raiſe Batteries on the Creſt of the Glacis, againſt the Flanks of the Baſtions attacked, they muſt alſo have been under a Neceſſity of

taking four Lunettes; which would have greatly prolonged the Siege. But as Bombs are almoſt as effectual in diſabling and diſmounting Cannon, as Counterbatteries of Cannon; and as there is a Poſſibility of diſmounting every Gun that is planted in the Flank of a Baſtion, by a Number of Bombs thrown inceſſantly into it; ſo the Enemy may ſtill, and without raiſing any Counterbattery on the Glacis, carry an Epaulment over the great dry Ditch, or paſs that Ditch without one, as in the End of the late Siege of Bergenopzoome, whatever Precautions the Beſieged take to prevent and diſappoint this Way of Aſſault; for the Beſieged will have, in this Caſe, the Muſquetry only, and thoſe chiefly who are poſted in the low Flanks, to truſt to. But if Mr. Coehorn had conſtructed a ſubterraneous Battery of 3 or 4 Cannon in the high Flank of each of the Demibaſtions of the Front which was attacked in the late Siege, in place of the vaulted Batteries, which he has given to ſome ſquare Orillons, theſe ſubterraneous Batteries muſt neceſſarily have obliged the Enemy to take the two collateral Lunettes, in order to dreſs Batteries againſt them; and the Expence of theſe caſmated Batteries would not amount to a great deal, becauſe there was no Occaſion for them in any other Front of Bergenopzoome, beſides that which is formed by the Baſtions Coehorn and Pucelle, and their intermediate Curtain; and in the right Flank of the Baſtion King William; and the left Flank of the Baſtion Belvidere: And tho' the Counterbattery of the Aggreſſors ſhould be ſuppoſed to ruin the caſmated one of the Flank in one Day, yet the End required is obtained, *viz.* Obliging them to dreſs Batteries againſt the Flanks of the Demibaſtions of the Front attacked; previous to which they muſt take the two collateral Lunettes, which muſt add greatly to the Length and Fatality of the Attack. Perhaps it may be objected to theſe caſemeted Batteries, that they do not vent well the Smoke; and therefore will be of little Uſe: But as theſe of the Flanks, whoſe Platform will be about the Level of the Field, will have a free Communication with the external Air, by the Archways leading into them, they will not fail, I imagine, to vent readily the Smoke; and by their being alſo as high as poſſible, they will be leſs commanded by the Counterbatteries of the Enemy. But if they will not yet be allowed to vent freely the Smoke, that Inconvenience may be infallibly remedied by drawing Air into them through iron Tubes, by means of Fire, in the manner that freſh Air has been conveyed into the Holds of ſome of our Men of War; occaſioning thereby a ſucceſſive Change of Air. This artificial Wind will drive the Smoke inſtantaneouſly out at the Vents which open obliquely in the Terreplain of the Baſtion above, and at the Port Holes. Such vaulted Batteries, if conſtructed in the Flanks abovementioned, would have been then, as I conceive, an Improvement; becauſe the Strength of the Front which is formed by the Baſtions Coehorn and Pucelle, is inferior, in my Opinion, to the Sum of the Strength of the weakeſt Part of the Lines of Halteren, or Kykinpot, and the weakeſt Front of the Place within either of theſe Lines together, ſuppoſing the Lines to be well manned; and becauſe the Expence, as I have already obſerved, would be thereby very little augmented, ſince I only ſuppoſe the vaulted Batteries in the high Flanks to be ſubſtituted in the Room of thoſe of the ſquare Orillons.

81. The Terreplain and Breaſtwork of the Orillons are lower than thoſe of the Baſtions, for the Reaſons already mentioned (6); but as the Damage which the Breaſtwork may ſuffer (27, 28) by the Fire of the diſtant Batteries, may be eaſily repaired, eſpecially after the Beſiegers have raiſed their third Parallel; and as the Bottom of the Ditch of the Ravelin may be well enough ſeen from the Face of a higher Orillon, by ſloping ſomewhat more the Ambraſures, ſo it would be better to have the Orillon juſt as high as the Face of the Baſtion; becauſe it will then not only bear as well againſt the Bottom of the dry Ditch of the Ravelin, by giving a little more Slope to the Ambraſures, but will alſo command it more powerfully, as well as the Counterbattery of the Aggreſſors on the oppoſite Counterſcarp, and their Lodgements on the covered Way of the Ravelin, and in the Gorge of the Lunette; which are conſiderable Advantages. The Battery of three Cannon of the left Orillon of the Baſtion Coehorn, was ſilenced by the Counterbattery of the Enemy, in the End of the ſecond Day, altho' the Beſiegers directed their Fire chiefly againſt the Revetement or Stone Wall of the Orillon: Tho' I am ſenſible the Enemy's Cannon were heavier than thoſe of the Beſieged, and their Gunners more alert than thoſe who ſerved the Battery of the Orillon; which alſo contributed to their Succeſs. But Mr. Coehorn could not avoid lowering the Face of the Orillon, without incurring another Diſadvantage; ſince the high Flank of the Baſtion would be, in that Caſe, deprived of the Reinforcement which it derives from the high Flank of the Orillon (5). In the following Methods this may be avoided, by giving a greater Length to the Perpendicular; preventing, at the ſame Time,

one of the principal Inconveniencies which a longer Perpendicular would induce, by diverging the Counterſcarp (74); or by adding an extenſive Flank of the Gorge; or by bringing, by a particular Conſtruction, other Fronts to bear againſt the great Ditch and its Counterſcarp, without incurring any other material Diſadvantage.

82. In the late Siege of Bergenopzoome, the Ravelin was aſſaulted, and carried at once by the Enemy, together with the Body of the Place, before the Beſieged had time to blow its Countermines; by reaſon it had no Redout or good Retrenchment: But the Ravelin was too ſmall to allow of a tolerable Retrenchment, or Redout; nor could ſuch a Redout be well flanked, becauſe the Face of the Ravelin was in a right Line with the Extremity of the Face of the Orillon; which Inconveniencies are neceſſary Conſequences of the Overnarrowneſs of the Front (47), and are avoided in the following Methods with great Lunettes, whoſe Fronts are more extended.

83. The Revetement, or Wall of Maſonry of the Faces of the Baſtions of Bergenopzoome, ſhould have been carried up within 7 or 8 Feet of the Creſt of the Breaſtwork, with a Berm at the Top of it, of one Foot, or a Foot and an Half only, for the Reaſons already mentioned (19); whereof we cannot ſuppoſe Mr. Coehorn was ignorant. The Sum to which he was limited has obliged him to make the Revetement low and thin, and conſequently to retire the ſuperincumbent Rampart, to eaſe, as much as poſſible, its Preſſure againſt the Wall; leaving of Neceſſity a large Berm at the Foot of the earthen Rampart. In our Methods the Stone Wall, by giving it a greater Slope, will admit of being made thinner, and may therefore be carried

up to a proper Height at a much leſs Expence: And Mr. Coehorn has been doubtleſs of Opinion, that the Sum that was neceſſary for reveting the Baſtions to the Foot of the Breaſtwork, would be productive of a greater degree of Strength, by applying it towards enlarging and reveting the Lunettes; and that the Diſadvantages of a large Berm, and of the eaſy Slope of the earthen Rampart are not very conſiderable, if the Defence is good (19).

CHAP. VII.

Of the Defences of the firſt Method.

84. IN the Conſtruction of this Method, Pl. 3. I have endeavoured to retain, nearly, all the Advantages of Mr. Coehorn's Method of Bergenopzoome, and have added others which were wanting in that Fortreſs, without incurring any of the Imperfections which were obſervable in the Works thereof in the late Siege. This Syſtem is conſtructed on a Hexagon whoſe exterior Side is 160 Toiſes; in conſequence whereof, the Advantages already mentioned are obtained (35 to 48); and the Diſadvantages peculiar to a much larger or narrower Front avoided. The Outworks are flanked in as direct a manner as is conſiſtent with other Conſiderations; that is, as is poſſible, without inducing ſome Inconvenience greater than the Advantages from thence ariſing, and alſo in the ſix following Methods. The ſtraight high Flank of the Baſtion is 26 Toiſes in Length; and the Chord of the Arch of the low convex Flank which forms the interior Line of its Breaſtwork, is 13 Toiſes; and the Redout of the Ravelin is large, and well flanked, and its Flanks are capacious.

85. The Heights of the ſeveral Works, and the Depths of their Ditches are as follows. The Baſtion has the Creſt of its Breaſtwork, at the ſaliant Angle, 21 Feet above the Level of the Field; at the Shoulder, the Flanks and the Curtain 18; and the low convex Flanks are 12 Feet above the Bottom of the dry Ditch. The Creſt of the Breaſtwork of the Ravelin is 17 Feet above the Field, at the ſaliant Angle, and 16 at the Extremities of its Faces: The Redout is 13 Feet high at the ſaliant Angle, and 12 at the Shoulders and Flanks. The Creſt of the Breaſtwork of the Lunette is 14 Feet, the covered Way 3, and the Creſt of the Glacis 9 above the Level of the Field. The Depth of the great Ditch is 18 Feet, and its Bottom is ſuppoſed to be within one Foot of the Level of the ſubterraneous ſummer Water, as that of Bergenopzoome; its Breadth is 15 Toiſes at the ſaliant Angle; and its Cunette is 7 Feet deep, and 12 broad. The Ditch of the Ravelin is 13 Feet deep, and its Bottom is 6 Feet from the Surface of the ſubterraneous Water; its Cunette is 4 Feet deep, and 6 broad: The Ditch of the Redout is on the Level of the Surface of the Field, and its Breadth at Top is 4 Toiſes. The Bottoms of the Ditches of the Lunettes are alſo on a Level with the Field, and 3 Toiſes broad.

86. In the high Flank of the Baſtion there is ſuppoſed to be a vaulted Battery of four Cannon, from x to x, whoſe Platform is nearly on a Level with the Surface of the Field; the Uſe and Intention of which are already ſet forth (80). The low convex Flanks (H) of the anonymous Author, which I have added, are chiefly intended for Muſquetry, and they will have a good Effect, and contribute not a little to oblige the Enemy to carry an Epaulment to the Foot of the Breach,

and to retard that Work, eſpecially if there are no caſemated Cannon, the Guns of the Flanks being, if uncovered from Bombs, not much to be depended on, if theſe are thrown in great Profuſion.

87. It may be remarked, that the Ditch of the Redout of the Ravelin, its Bottom being even with the Surface of the Field, may have Galleries puſhed under it; and that the Beſieged will not therefore be obliged to erect a Battery on the Ravelin to open the Redout; alſo that its Breaſtwork is lower than that of the Ravelin: The Ditch of the Redout, in order to prevent the Enemy from puſhing Galleries under it, muſt be carried down to the Depth of 16 Feet, that is, 3 Feet from the Surface of the Water; if ſo, the Bottom of it, near the Shoulders of the Redout, cannot be ſeen from the convex Portions of the Flanks of the Baſtions; and its Breadth, which is four Toiſes at Top, would be leſs than three Toiſes at Bottom, at $\frac{1}{5}$ of the Height of Slope to its Eſcarp and Counterſcarp: Therefore a well charged Mine being ſprung, whoſe Chamber is nearly as low as the Water, and at a proper Diſtance from the Wall of the Counterſcarp of this narrow Ditch, in Proportion to the Depth of the Mine, would infallibly fill up the Ditch with the Ruins ſo high, as to allow of another Mine to be puſhed under theſe Ruins of the firſt; ſo then all that could be gained by giving ſuch an immenſe Depth to the narrow Ditch of this ſmall Piece, which, on Account of the high Revetement, would increaſe conſiderably the Expence, is no more, than to oblige the Enemy to puſh that ſecond Mine, which would be wholly free from the Chicanery that is liable to be practiſed on the covered Galleries of the Miner which are compoſed of Barrels, Blinds and Faſcines.

88. I make the Breaſtwork of the Redout 4 Feet lower than that of the Ravelin, becauſe it not only ſaves Expence, but is preferable, I imagine, to a greater Height; and the Counterſcarp of its Ditch is raiſed 6 Feet above the Surface of the Field, by which means it is well ſeen, and commanded from the Faces of the Redout: Whereas, if the Redout is ſuppoſed as high as the Ravelin, and the Counterſcarp of its Ditch as low as the Surface of the Field, the Lodgement of the Enemy on the Verge of the Counterſcarp will not be ſeen from the Faces of that high Redout, which is a conſiderable Diſadvantage, eſpecially in Mr. Vauban's third Method, by reaſon the Redout of its Ravelin is badly flanked; ſuch a high Redout is alſo leſs commanded by the Body of the Place: Beſides, our low Redout anſwers ſufficiently the principal Intentions of its Conſtruction; which are to put a Stop to the Carrier of the Aſſailants, and oblige the Beſiegers to make themſelves Maſters of the Countermines of the Ravelin as they advance their Sap; which will gain much Time; nor can they reduce the Redout otherways than by opening its Rampart by Cannon, or by a Mine, after having made themſelves Maſters of the Countermines of the Ravelin; and as it is well commanded, the Enemy will meet with great Difficulty in eſtabliſhing Lodgements thereon.

89. The Inſide of the Breaſtwork of the Faces of the Ravelin is directly ſeen and flanked from the Shoulders of the Baſtions, and the Curtain; which will occaſion the Sap of the Enemy to be puſhed forwards, in theſe Faces, with the utmoſt Difficulty and Danger (75): And therefore Traverſes muſt be, if poſſible, avoided, or leveled as ſoon as the Enemy's Approaches have reached the Creſt of the Glacis.

cis. The Lunettes are of a juſt Proportion, in reſpect of the Baſtions and Ravelins, ſo as to poſſeſs, in the greateſt Perfection, all the Advantages that can be obtained by means of Works of that Kind; and they are flanked and commanded in the ſtrongeſt Manner.

90. The Ditch of the Ravelin is leſs deep by 5 Feet than the great Ditch, that it may be well ſeen from the Face of the Baſtion; and its Cunette will prevent the Enemy from puſhing a Gallery under it. This Ditch riſes 2 Feet at its Extremities, where it joins the great Ditch, forming a Breaſtwork or Traverſe, whoſe Creſt is 7 Feet above the Bottom of the great Ditch; which may be lined with Muſqueteers, and have a good Effect: The Space for the Muſqueteers is covered on the Side of the Counterſcarp of the great Ditch, by the re-entring Angle of the Gorge of the Lunette; and may be ſtill more ſo by a ſmall oblique Traverſe (Y). The Communication between the great Ditch and the Ravelin may be open, or caſemated in the Spaces K, K, behind the Orillons of the Redout. The Baſtions are hollow for the Reaſons already mentioned (49 to 55.); and the hollow Spaces will be convenient for encamping Part of the Gariſon during a Siege. The great Gallery of the Counterſcarp is ſuppoſed to be conſtructed after the Manner of that of Bergenopzoome. The other Particulars relative to the Defences of the Works of this Method are ſet to View in the firſt Section concerning the Works of Bergenopzoome, and in the fifth Chapter of the ſecond Section.

CHAP.

CHAP. VIII.

Of the Defences of the ſecond Method.

91. THE ſecond Method, Pl. IV. is rather more complex, but leſs expenſive than the firſt; and is ſuppoſed to be conſtructed with a wet Ditch, which has the Surface of the Water within 3 Feet of the Level of the Field. The Creſt of the Face of the Baſtion is 19 Feet high above the Level of the Field; the Creſts of the high Flanks and Curtains 18. The high Flank B of the retired Face 19, the low Flank D 13, the Foſſe-bray E 6, and the convex low Flank O of the Baſtion 8. The Face of the Ravelin to the Creſt of its Breaſtwork is 15 Feet, and its Redout 7 above the Field. The Lunettes are 12 Feet high, and the Creſt of the Glacis is 6; and the covered Way is on a Level with the Field. The great Ditch is 15 Feet deep, the Ditch of the Ravelin 13; and the Ditch of its Redout, and thoſe of the Lunettes in the covered Way, have their Bottoms 3 Feet below the Surface of the Field, that is, on a Level with the Surface of the ſubterraneous Water; and the Fore Ditch is 10 Feet deep.

92. The Baſtion of this Method, whoſe Conſtruction is ſomewhat ſingular, has a retired Face A, which has two high Flanks (B, C,), and one low Flank (D), and a Fauſſe-bray (E); by which means, the Flanks of the Baſtion are re-inforced by the Addition of a conſiderable Fire againſt the oppoſite Counterſcarp N M, and the Paſſage of the great Ditch, without weakening the Baſtion, or diminiſhing the Quantity of the direct Fire of its Faces againſt the Field,

the Outworks and their Ditches. The high Faces are, in conſequence of this Conſtruction, leſs liable to be ſcoured by the Ricochet, and the retired Face (A) is leſs expoſed to the direct Fire of the Batteries of the Enemy in the Field; neither can the Fauſſe-bray be ſcoured by the Ricochet, nor plunged into by the Cannon of the Enemy on the Counterſcarp; and its Platform is ſufficiently capacious. I know no Objection, of any weight, that can be made to this Conſtruction, or that will come near to balance the Advantages which attend it; eſpecially as the Fire of the Flanks of the retired Faces, by being very near its Object, will be more certain and efficacious. If the Baſtion is not reveted, the Expence thereof will be leſs than if it were made in the common Way; and if it is reveted, the Expence will not amount to a great deal more.

93. Perhaps it may be ſaid, that the Beſiegers, by directing the Fire of their Battery on the Counterſcarp, obliquely againſt the Flanks B, D, of the retired Face, will ſoon accompliſh a mountable Breach: If they direct their Fire againſt theſe Flanks, their Cannon will alſo come to be more expoſed to the great Flanks of the collateral Baſtions, which, together with the Fire of the Flanks of the retired Face, will overpower any Battery that the Enemy can raiſe againſt them on the Counterſcarp: But ſuppoſing that the Battery of the Enemy ſhall ruin in a great meaſure the Flanks B, D, notwithſtanding of the ſuperior Fire of the Beſieged, or at leaſt, ſhatter them ſo as to render it practicable for the Aſſailants to ſcramble up that Way into the Baſtion, which I believe is very poſſible; yet the Aggreſſors, before they can approach the ſaid Flanks, muſt carry a Paſſage over the great Ditch, and by the time that is

done, theſe Flanks will have had their Effect; which conſiſts in contributing to retard and ruin the Lodgements and Batteries of the Enemy on the Glacis and covered Way, and their Paſſage of the great Ditch. But theſe Flanks (B, D,) of the retired Face are defended by the oppoſite high Flank C, which cannot have its Cannon diſmounted, or its Defences ruined by the Cannon of the Enemy on the Counterſcarp or Outworks, by reaſon of its oblique Poſition with reſpect to theſe Works: So that the Beſiegers, if the Defence is good, cannot ſucceed that Way; or the Beſieged may, at leaſt, obtain a Capitulation, after the Paſſage of the great Ditch is carried to the Face of the Baſtion. This Method will alſo be good without the low Flanks (D) of the retired Faces; and in that Caſe the Beſiegers will not think of determining their Attack that Way. The Defence afforded by the high Flank C, to the oppoſite Flanks B, D, would be ſtill greater, and infallibly render abortive any Attempt of the Enemy towards mounting to the Aſſault of the Baſtion by theſe Flanks, provided its Revetement were conſtructed with a vaulted Gallery with Loop-holes for Muſquetry. The retired Face of the Baſtion and its high Flanks are the more advantageous, becauſe their Cannon can ſcarce ſuffer any Damage from the Fire of the Enemy's Cannon on the Counterſcarp, ſince theſe cannot be brought to bear againſt the former without giving them a very high Elevation; and becauſe the Effect of the Cannon of theſe Flanks againſt the Lodgements and Batteries of the Enemy on the covered Way and Creſt of the oppoſite Glacis, will be very great on account of their Proximity and ſuperior Height, in reſpect of theſe Outworks.

94. The low convex Flanks of the anonymous Author (o) have, in this Method, with a wet Ditch, the Advantages which attend theſe in a dry one (86), beſides incloſing and covering a ſmall Harbour, convenient for Boats and Floats for conveying Artillery and other neceſſary Stores into the Outworks, and for tranſporting the Guards of theſe Pieces when their ſlender Bridges of Communication may happen to be broke down.

95. As the Beſiegers, when they are lodged on the ſaliant Angle of the covered Way of the Baſtions and Ravelin, may render, by a continual Fire of the Muſquetry in the Nights, the Communication of the Beſieged with the Lunettes very dangerous and difficult in a wet Ditch; and as the Lunettes, whoſe Ditches are wet, or carried down to the Surface of the Water, will be ſtronger than thoſe whoſe Ditches are dry and high above the Level of the ſubterraneous Water, if the Communication can, by any means, be rendered ſafe; becauſe the Beſieged will be obliged to open a Breach in the former with Cannon, which will not be eaſily effected, ſince their covered Way and the Creſt of their Glacis, are commanded in the ſtrongeſt Manner by the Faces of the Baſtions and Ravelins; ſo I have, with the View of aſcertaining this Communication of ſo much Conſequence in this Conſtruction with a wet Ditch, conſtructed Caponieres, or double covered Ways (H) in the Ditches of the Ravelins, whoſe exterior Breaſtwork is of Earth, 2 Toiſes thick, and faced with a Wall of Maſonry, and the interior is a thin Stone Wall; the exterior one has a Footbank on its inward Side, and the intermediate Space between the two Breaſtworks of this Caponiere is carried down 5 Feet below the Surface of the Water, and is flanked from the interior Con-

cave Portion of the Flank (G) of the Baſtion. That this Caponiere of Communication may have no bad Effect, by facilitating the Enemy's Paſſage of the Ditch of the Ravelin, the exterior Side of its outward Breaſtwork is alſo flanked by one caſemated Gun immediately behind the Orillon of the Ravelin at I, which can be ruined only by a Battery raiſed in the Gorge of the Lunette, which is ſcarce practicable, by reaſon it is ſo much commanded by the Baſtion, the Curtain and the Ravelin; ſo that this Caponiere can be of no manner of Uſe to the Enemy.

96. The Flanks of the Ravelin are nearly perpendicular to the covered Way of the Baſtions, which conſequently they command well. The Redout L of the Ravelin, as it is intended in this, by reaſon of its Smallneſs, chiefly as a Retreat to the Guard of the Ravelin, is only 7 Feet above the Level of the Field, that the Terreplain of the Rampart of the Ravelin may be well ſeen, and commanded over its Creſt by the Place. The Lunettes are not, in this Method, ſo large as in the firſt, chiefly that their Fore Ditch, and its Counterſcarp, may be better flanked and commanded from the Faces of the Baſtions and Ravelins.

97. From the Extremity or Counterſcarp of the Fore Ditch, the Ground is ſuppoſed to be cut down within half a Foot of the Surface of the Water, to the Diſtance of about 10 Toiſes, and afterwards to aſcend by a gentle Slope to the Level of the Field; which will be leſs expenſive, and in my Opinion, much preferable to a Second covered Way, which, as Mr. Goulon very juſtly obſerves, is eaſily forced, on account of its Diſtance from the interior Works; and the Creſt of its Glacis afterwards affords the Enemy a convenient Lodgement, which is ſecured from the Sallies of

the Beſieged by the Fore Ditch, and which ſuſtains well their Lodgement on the firſt Glacis: Whereas, in this Method, where the Counterſcarp is cut down nearly to the Level of the Summer Water, the Enemy's Trenches of Approach will be puſhed on to the Verge of the Fore Ditch, and their Lodgement thereon eſtabliſhed with the utmoſt Difficulty and Danger, as they will be under a Neceſſity of tranſporting their Earth, and be as much expoſed, or rather more, than in carrying a Paſſage over the wet Ditch; ſince they will be ſeen, not only in Front, but in either Flank, from a large Front of the Fortreſs; and their Lodgement will alſo, in conſequence of its Lowneſs, be better commanded by the interior Works. For this Reaſon, the Glacis ought to be as narrow as poſſible, without incurring Inconveniencies greater than the Advantages from thence ariſing, that the Fore Ditch and the contiguous low Ground in its Front, may be well flanked and commanded by the interior Works. This naturally leads me to conſider, whether a narrow Glacis about 4 Toiſes in breadth, as that of Fort St. Iſabel at Boiſleduc, and ſome other Places in the Low Countries, or one of 15 Toiſes, is in this Caſe preferable.

98. The narrow Glacis of 4 or 5 Toiſes will be attended with the Advantages juſt mentioned (97), in a greater degree than the one of 15 Toiſes; the Enemy can have no Trenches with Cavaliers to command its covered Way, unleſs they raiſe theſe Cavaliers in the Fore Ditch, on account of the Narrowneſs of the Glacis; and their Batteries thereon will be eſtabliſhed, and ſerved with more Difficulty, by reaſon of their being pinched in Ground, and confined to ſo narrow a Space: Sorties will alſo be more ſucceſsful

againſt them; for if they are beat out of the Lodgement on the Glacis by a ſtrong and brisk Sally, they will be forced into the Fore Ditch before they can have time to recover themſelves.

99. But this narrow Glacis is, on the other hand, liable to the following Inconveniencies, from which the one of 15 Toiſes is exempt. Its Surface muſt either not be ſeen from the Face of the oppoſite and interior Works, and a conſiderable Part of it at the re-entring Angle, from the Work that flanks it, and ſo will alſo be rendred weak, by reaſon of the great Slope; or it muſt have at its Extremity, in conſequence of a gentler Slope, ſo as to be wholly ſeen from theſe Works, a perpendicular Height of at leaſt four Feet above the Surface of the Water of the Fore Ditch, which will occaſion a great Part of that Fore Ditch that it cannot be ſeen from the interior Works; and the Approaches of the Beſiegers to the ſaliant Angles of the Glacis thro' the Fore Ditch, will therefore be leſs difficult and dangerous; and their Paſſage of that Ditch will be always covered, in a great meaſure, on the Side of the ſaliant Angle, by the high Extremity of the Glacis, from the Fire of the collateral Works of that Side; which are conſiderable Advantages in favour of the Enemy: And when they approach the re-entring Angles, the Glacis, after filling up ſome Part of the Fore Ditch for a Platform, will afford them a ready-made Epaulment for Batteries of Mortars, for throwing Bombs and Flights of Stones and Grenadoes into the Works attacked. Beſides, there is a Poſſibility of battering in Breach, the Faces of the Works, from the Counterſcarp of the Fore Ditch, after levelling ſome Part of this narrow Glacis by Cannon, Fougaſſes, or otherways.

Where the Glacis is 15 Toiſes broad, theſe Diſadvantages are almoſt wholly avoided; but even in that caſe the Foot of the Glacis will be frequently, after a great Drought, 2 Feet perpendicular above the Surface of the Water of the Fore Ditch, which, however, is but trivial in compariſon with the former: And were the Glacis made much broader, ſuppoſe 30 Toiſes, it would occaſion the Fore Ditch to be badly flanked, and the low Ground in its Front, to be much leſs commanded. Upon the whole then, I am of Opinion, that the Medium, *viz.* 15 Toiſes of breadth, is the beſt; and that the narrow Glacis is only to be practiſed where the Water of the Fore Ditch may be dammed up as high as the Extremity of the Glacis; provided alſo that this Inundation cannot be eaſily drained.

CHAP. IX.

Of the Defences of the third Method.

100. IN this Method, Pl. v. the Ditch is ſuppoſed to be dry, and high above the ſubterraneous Spring. It is compounded of the firſt and ſecond Methods, with an exterior Enceinte in Imitation of Mr. Coehorn's at Nimeguen; conſequently the Defences of the Baſtions and Outworks of the firſt Enceinte may be underſtood from what has been ſaid in the two preceding Chapters. As the Ground is ſuppoſed high above the Surface of the ſubterraneous Water, ſo we have given no Cunettes to the Ditches, ſince they are not in this Caſe productive of any material Advantage, and might poſſibly have a bad Effect. The interior covered Way is on a Level with the Field; and the

Ditches of the interior Lunettes are 4 Feet below the Surface of the covered Way.

101. Mr. Coehorn having obſerved, that advanced ſingle Lunettes were liable to be cut off from the Communication of the interior Works by the double Sap; which Lunettes may be of excellent Uſe, by flanking the Approaches of the Enemy, and ſeeing them in reverſe, and obliging the Beſiegers to open their Trenches at a greater Diſtance from the Place; and as theſe advanced Lunettes would give the Beſiegers abundance of Trouble, provided they were ſo contrived as to put them under a Neceſſity of opening them by Mines, or Cannon; ſo he has very ingeniouſly diſpoſed them in ſuch a Manner at Nimeguen, *viz.* in Chains, which conſiſt of three or four Lunettes each Chain, as to render it impracticable to cut them off by Sap; and by having them detached from each other, the Beſiegers are obliged to take each Lunette by a ſeparate and regular Attack. The exterior Enceinte of this Method differs in ſome Things from that of Nimeguen, which was not finiſhed when I had an Opportunity of ſeeing it; ſo that I have finiſhed this one according to my own Fancy, ſo as to form it into a Method.

102. It will be proper, before we treat of the Defences of this Enceinte, to give ſome Account of the Conſtruction of it. The Foot of the Glacis of the firſt, or interior Enceinte, is carried down 3 Feet below the Surface of the Field, and the whole intermediate Space between the Foot of that Glacis and the covered Way of the exterior Enceinte, and alſo the Ditches of the advanced Lunettes of this Enceinte, are on the ſame Level, *viz.* 3 Feet lower than the Surface of the Field; and the ſaid exterior covered

Way is upon a Level with the Field; and the Earth which is taken from this low intermediate plain Space, is applied towards raiſing theſe advanced Lunettes, and the exterior Glacis. The Creſt of this Glacis is 6 Feet above the Level of the Field; and the Faces of theſe exterior Lunettes, which are reveted to the Foot of the Breaſtwork, are 11 Feet; and conſequently 14 Feet above the Bottoms of their Ditches: Their Gorges are alſo reveted with a Wall 8 Feet high; but the ſingle Demiredouts (z) in the Intervals of the Chains have no Revetement; their Gorges, however, are ſuppoſed to be well paliſadoed, and their Ramparts frazed: By means of this Conſtruction, theſe advanced Lunettes and Demi-redouts of the exterior Enceinte are better ſeen into, and more commanded by the interior Works; and better covered from the Field, eſpecially as their Ditches and covered Way are narrow.

103. The Lunettes of theſe Chains command well the Glacis and the Field, without being much expoſed to the Fire of the Enemy; and their Ditches and covered Way are flanked by ſmall detached, low, broken Curtains (N); and by their being diſpoſed in Chains, it is evident that the Aggreſſors can never cut them off ſingly by Sap, nor take any one of them by open Force; and if they attempt to cut off a whole Chain, they will not be able to ſuſtain their tranſverſe Sap on the Side of the Place; their Caponieres of Communication (P, Q,) with the Place being double, will alſo, if lined with Muſqueteers, ſtrengthen their Gorges againſt tranſverſe double Saps, and ſudden and unexpected Attacks by Eſcalade; and alſo ſerve as Counter-approaches to flank the Trenches of the Enemy, after they are advanced within the exterior Enceinte. The ſmall Caponieres (x) are intended to

flank the outward Faces of the two collateral Lunettes of each Chain, which are at too great a Diſtance to be commanded in the Nights from the Faces of the Ravelins which flank them, and theſe may be made occaſionally in the Fronts attacked.

104. Now, if we ſuppoſe the Beſiegers to carry on one Attack only againſt the Place thus fortified, ſuppoſe againſt the Baſtion B, they will be obliged to take the oppoſite Chain of advanced Lunettes (F, G, H); then the two Lunettes D, D, of the interior Enceinte, and one Ravelin, ſuppoſe the Ravelin E; but the Beſiegers, before they can take this Ravelin (E), muſt raiſe a Battery on the Glacis at L, before its left Face, to command the Face of the Baſtion at S, which flanks the Ditch of the right Face of that Ravelin: But the Beſiegers cannot raiſe that Battery, until they are Maſters of the Lunette A (25), therefore they muſt alſo take this Lunette; neither can they make themſelves Maſters of the Lunette A, until they have taken the advanced Lunette K, becauſe from thence, their Approaches and Lodgements of the Attack of the interior Lunette A, would be ſeen in Reverſe: When this is done, and the Beſiegers have taken the Lunette A, they will alſo command the Caponiere M, and the Flank of their Attack on that Side will be wholly ſecured. Conſequently the Aggreſſors, before they can be Maſters of this Baſtion B, muſt take nine Pieces, excluſive of the advanced Demi-redout (O), and the Redout (C) of the Ravelin.

105. But if the Beſiegers attack two Baſtions, they muſt take in all 13 Pieces, the Baſtions included; *viz.* two Chains of advanced Lunettes, four interior Lunettes, one

Ravelin with its Redout, and two Baſtions; beſides one advanced Demi-redout.

106. This Method is to be practiſed chiefly in ſmall Towns, eſpecially thoſe in Form of a Semicircle, or ſmall Segment of a Circle, ſituate by the Sides of large Rivers, the Diameter or Chord of the Arch forming the long Side next the River, as in the Caſe of Nimeguen on the Waal, becauſe the Expence of it will in that Caſe, be leſs immenſe; and becauſe it will be highly uſeful in ſmall Places whoſe Situations are ſuch; ſince it will afford ſufficient Space, that will be free from, or not much incommoded by the Fire of the Beſiegers, for encamping the Gariſon during a Siege. Nor will this Method require ſo great a Gariſon as moſt People might, at firſt View, be apt to imagine; for if the exterior Enceinte has ſufficient Guards, the interior Works will be thereby alſo ſecured, and require but few and inconſiderable Guards; and in the Nights Surprizes are guarded againſt by the proper Diſpoſition of the Piquets of the Gariſon, and by reinforcing ſuch of the Guards as are judged neceſſary.

107. I chooſe to give this Method great Lunettes in the firſt covered Way, becauſe they contribute greatly to command well the exterior Enceinte, and the Caponieres of Communication; and they augment, in a great Degree, the Strength of the Fortreſs. But if a ſmall Place is to be fortified, the Inportance whereof is not equal to the Expence of fortifying it preciſely according to this Method; in that Caſe, the firſt, or interior Enceinte may be made more ſimple; and according to the fourth, or ſeventh Method, but rather the fourth, becauſe this latter will ſhew a greater Front to, and command better the ſecond covered

Way with its Lunettes and Demi-redouts; and the exterior Enceinte will be of great Advantage, by enlarging, as we have already obſerved, the Circumference, and augmenting, in a great degree, the Strength of ſuch a Place of ſmall Compaſs.

108. If the Place to which this Enceinte is to be added has the circumjacent Ground uneven, with ſome Spots of high commanding Ground, and others falling off from the Place by an eaſy Deſcent till they ſink without the View of the Ramparts of the Fortreſs, the Diſpoſition of the chained Lunettes muſt be ſuch, as to command or occupy as much as poſſible the commanding Grounds, and ſo as to diſcover, and ſee into the Bottoms of the deſcending Grounds; having, at the ſame time, as much regard to the Diſpoſition of them in this Method as is conſiſtent with theſe Conſiderations. In this manner Mr. Coehorn has judiciouſly diſpoſed them at Nimeguen.

109. It may not be improper to obſerve here, that the Weakneſs peculiar to Fortreſſes of narrow Compaſs, is not, according to the Idea of a late Author, altogether owing to the Space within the inward Incloſure being too ſmall to quarter a Gariſon ſufficient for the Defence of the Fortreſs; but that Weakneſs is evidently occaſioned by the Gariſon, their ſick and wounded, their Horſes, military and victualing Stores, and Magazines of Powder being every where within the Reach of the Enemy's Fire; for in ſuch a Caſe it is the Intereſt of the Beſiegers to reſerve one Bomb-battery for annoying the Town: This I ſay is the principal Cauſe; for the Beſieged are not ſuppoſed to be under a Neceſſity of quartering in the Town, nor is it proper they ſhould be lodged in Houſes during a Siege, ſince they may be en-

camped on the Terreplain of the Ramparts, and in the hollow Spaces of the Works, and in the dry Ditches (if there are any) that are moſt remote from the Enemy's Fire, or leaſt liable to be annoyed thereby; and with greater Advantage, becauſe they will then be eaſier aſſembled, and may form more readily on any Emergency. Beſides, a Place of very ſmall Compaſs will contain Barracks ſufficient to lodge a very ſtrong Gariſon; and if it ſhould not, the State will always have time to throw in Reinforcements when there is a Probability of its being beſieged; and we have had many Inſtances of Citadels and other ſmall Places making very long Defences. In Places of very ſmall Extent the Gariſon may be lodged behind ſtrong Planks laid ſloping againſt the Breaſtworks and Ramparts; the interior Slope of the latter being cut down ſteeper for that Purpoſe. A Piazza about ſeven Feet high and twelve broad, under the inward Side of the Ramparts, would anſwer ſtill better this Purpoſe. So that a Place of very ſmall inward Compaſs, with Works extending to a great Circumſerence, is capable of encamping and lodging a Gariſon ſufficient for its Defence.

CHAP. X.

Of the Defences of the fourth Method.

110. THIS Method, Pl. VI. is formed on the ſame Principles as the ſecond; that as much Front as poſſible may be brought to bear againſt the Counterſcarp of the great Ditch, and ſo as that the Advantages from thence accruing, do overballance a great deal the Diſadvantages; and theſe Advantages are obtained in a greater de-

gree in this Method, than in the ſecond; nor, indeed, do I know any Method that ſhews ſo much direct Front to the Counterſcarp, in proportion to the Expence and degree of Simplicity, and Diſadvantages incurred.

111. The Faces of the Baſtion of this Method, and the Faces, Flanks and Curtain of the ſmall Front that is conſtructed thereon, have the Creſt of the Breaſtwork 19 Feet above the Level of the Field; the Fauſſe-bray (H) of the Curtain of the ſaid Front 4 Feet; the Demilune G 3, and the Bonnet S of the ſaliant Angle of the covered Way before the Baſtion, when ſuch is conſtructed, 11 Feet: The Redout (L) of the Ravelin is 12 Feet above the Field, and the Bottom of its Ditch is carried down to the Level of the ſubterraneous Water, or Surface of the Water of the great Ditch; and the Ditch (H) of the Front of the Baſtion is 10 Feet deep The Heights of the Curtain, the high and low Flanks of the Baſtion, the Ravelin, the covered Way and Glacis, and the Depth of the great Ditch, and the Ditch of the Ravelin, are the ſame as in the ſecond Method. The Terreplain of the Demilune G, muſt be carried down 3 Feet below the Level of the Field, that the Muſqueteers behind its Breaſtwork may be covered from the Enemy's Fire, from their Lodgement on the Creſt of the Glacis; and temporary Traverſes (15) may be planted on the Platform of its Faces, to cover them in Flank.

112. The only Diſadvantage that I know this Method incurs is, that the Face (T) of the fronted Baſtion does not flank and command the Field, and the Foot of the Glacis before the Face of the Ravelin (K) ſo well as the common Baſtion; but if this is rightly conſidered, we ſhall find the Objection to be of ſmall weight. While the Approaches of

the

the Enemy are yet remote from the Counterſcarp, the Fire of the Baſtion contributes very little to retard them; and if the Beſieged oppoſe all the Batteries of the Enemy in the Field, it will only precipitate the Ruin of their Cannon, and, in effect, ſhorten the Siege; ſo that the great and principal Uſe of the Baſtion is to defend, flank and command the Creſt of the Glacis, the covered Way, the Outworks and their Ditches, and the great Ditch; and which the fronted Baſtion of this Method does in the ſtrongeſt manner: And the beſt Method of annoying, flanking and retarding the Approaches of the Enemy, is by planting ſmall Cannon in the moſt ſaliant Angles of the covered Way, and in the Angles of the Outworks, and playing them inceſſantly againſt the Head of the Sap, and in Ricochet into the Returns of the Trenches that are moſt liable to be flanked; making Merlons for thoſe in the ſaliant Angles of the covered Way, of Gabions filled with Earth, or of Faſcine-work, which will alſo cover, in a great meaſure, the covered Way near the ſaliant Angle from the Richocet, and from the Fire of the Muſquetry of the Cavaliers of the Trenches: Likewiſe by poſting Muſqueteers in theſe ſaliant Angles to keep a conſtant Fire againſt the Head of the Enemy's Sap: The Trenches of Approach, and the third Parallel of the Aggreſſors, may indeed alſo be ſucceſsfully retarded by Counter-approaches, when the Gariſon is ſtrong: But if this ſhould by ſome be ſtill inſiſted on as a Defect, it may be effectually remedied by raiſing a Bonnet (s) in the ſaliant Place of Arms of the covered Way, before the Front of the Baſtion, leaving a Space of two or three Toiſes between its Eſcarp and the Creſt of the Glacis, for Muſqueteers. This Piece, (s) whoſe Baſe is on a Level with the covered Way, is conſtructed at a ſmall Expence, and will alſo cover, in a great meaſure, the Front of the Baſtion from the Batteries of the Enemy in the Field, and therefore occaſion it to be kept more eaſily in repair; which, however, is pretty well covered, on account of its Diſtance from the Glacis, from theſe Batteries of the Enemy, ſuppoſing the Cannon of them to be lower than the Creſt of the Glacis. It will alſo prevent the covered Way from being plunged into by the Ricochet, or by ſmall Arms from Cavaliers in the Trenches.

113. The Intention of the Fauſſe-bray (H) in the ſaliant Front of the Baſtion, which is only 4 Feet above the Level of the Field, and 7 above the Surface of the Water, is chiefly to cover the Angles of the Flanks of that narrow and ſaliant Front, which cannot be ſeen by reaſon of the Shortneſs of its Curtain: It will alſo ſerve to lodge Muſqueteers for the Defence of the low Demilune G, and the ſmall intermediate Ditch. This Fauſſe-bray may be made alſo in form of a Redan, as is indicated by the pointed Lines, for where the Breaſtwork is ſo low, a dead Angle can have no bad Effect; and in this Shape it will command better the Ditch of the Demibaſtions of this ſaliant Front.

114. This Front of the Baſtion bears againſt all that Part of the Counterſcarp which is contained between P, P; excluſive of the Fire of the Flanks of the great Fronts, the Redouts of the two collateral Ravelins, the Faces of theſe Ravelins and of the Demilune G, and the oblique Fire of the collateral Curtains, which alſo bear againſt the greateſt Part of that Counterſcarp of the Baſtion; nor can the Front of the Baſtion be commanded by any Counterbattery

of Cannon on the Glacis or covered Way; and one Cannon mounted therein will have, at leaſt, as great an Effect againſt the Counterbattery of the Enemy on the Creſt of the Glacis, as can be produced by two Pieces of Cannon from the great Flank of the Baſtion (93). Therefore, the Beſiegers, if they attack one Baſtion only, ſuppoſe the Baſtion B, will be obliged to take the two collateral Ravelins and their Redouts, from whence the greateſt Part of the Counterſcarp of the great Ditch is commanded in the moſt direct Manner; and the Beſiegers will, even then, find the utmoſt Difficulty in commanding the Fronts which defend the great Ditch; and which cannot be done without an immenſe Expence of Shells, notwithſtanding of which, the Effect of the Fire of the Muſquetry of the Beſieged, may ſtill be conſiderable (86).

115. But the Beſiegers will endeavour, perhaps, to take the Place by making themſelves Maſters of one Ravelin only, and its Redout, ſuppoſe K, L; in that Caſe, they muſt raiſe their breaching Battery againſt the left Face of the Baſtion B, on the right Demigorge of the re-entring Place of Arms M, ſo as to be covered, as much as poſſible, from the Fire of the left Face of the collateral Ravelin Z, and the Flank of its Redout, and of the oppoſite Flank and Face of the Front of the Baſtion B; in that Caſe, this breaching Battery in the Place of Arms (M), will be expoſed to the oblique Fire of the whole Curtain X, and of the interior Extremity of the Flank C of the Demibaſtion A; and in a pretty direct manner to the Cannon of the Retreat F of the Curtain; the Efficacy of which Fire muſt neceſſarily be very great, by reaſon of the Smallneſs of the Diſtance; beſides the direct Fire of the oppoſite Face of the Baſtion,

which in this Caſe may be brought to bear eaſily againſt the oppoſite Place of Arms M, on account of the great Breadth of the great Ditch at the Place of Arms, in conſequence of the diverging Counterſcarp. The Paſſage of the great Ditch, which muſt, in this Caſe, be carried over from the re-entring Angle of the Counterſcarp to the Face of the Baſtion, will alſo be moſtly expoſed to the oblique Fire of the whole Curtain X, and wholly and directly to the high and low Flanks C, E, of the Demibaſtion A; which Paſſage will therefore, and by reaſon of its Proximity to theſe Fronts, be executed with the utmoſt Difficulty and Danger; and as this Paſſage will be ſeen in reverſe from the Demilune G, the Aggreſſors will be under a Neceſſity of making it with a double Epaulment. But the Beſiegers, that they may avoid the Difficulty of raiſing and ſerving a breaching Battery in the re-entring Place of Arms M, will perhaps content themſelves with battering the Face of the Baſtion in Breach, from the Counterſcarp Y, before the ſaliant Angle of the Ravelin; if ſo, the Beſiegers muſt carry the Paſſage of the great Ditch from the Extremity of the Face of the Ravelin K, to the Angle of the Shoulder of the Baſtion B, which will be ſtill more expoſed, and more directly to the Fire of the Curtain, and more commanded thereby, and by the Flanks of the Demibaſtion A; and proportionably more difficult to be executed: Beſides the Difficulty of making a mountable Breach at that Diſtance (159). From the whole then, it appears, that the Beſiegers will gain very little by conducting their Attack in this manner, and taking only one Ravelin; and I am of Opinion, it would be fully as advantageous for them, and much leſs precarious, to take two Ravelins with their Redouts,

douts, and afterwards to carry the Paſſage of the great Ditch over to the Demilune G, and from thence to the ſaliant Front of the Baſtion, after battering in Breach from the Demilune, or from the Counterſcarp, after razing ſome Part of the Breaſtwork of the Demilune. Conſequently, if the Beſiegers carry on two Attacks againſt a Front of a Fortreſs conſtructed according to this Method, they muſt take 7 Pieces, excluſive of the three Redouts of the Ravelins, and the two Bonnets of the ſaliant Places of Arms, *viz.* three Ravelins, two Demilunes, and two fronted Baſtions.

116. I make the re-entring Places of Arms ſmall, that the Creſt of the Glacis of their Faces, on the Side of the Baſtions, may be well flanked from thence; and that the Enemy may not have room to raiſe Batteries on their oppoſite Faces againſt the Fronts of theſe Baſtions. The Traverſes are raiſed at ſome Diſtance from the Faces of the Places of Arms, that the ſaid Faces may contain more Fire, and the intermediate Space more Troops; and that the Beſieged may have an Opportunity of making Retrenchments, or Traverſes, within the exterior ones, as thoſe marked with Points in the Place of Arms M.

117. The Ravelin is of a good Size, and the Inſide of the Breaſtwork of its Faces is flanked and commanded in the moſt direct manner from the Shoulders of the Baſtions, and from the Curtain, which will occaſion the Sap of the Enemy to be puſhed forwards therein with the utmoſt Difficulty.

118. The Redout of the Ravelin is alſo large, with long Flanks, which bear in the moſt direct manner againſt the oppoſite Counterſcarps, and the great Ditch; and, in Reverſe,

verſe, againſt the Face of the Baſtion, and are of excellent Uſe: And the whole Piece is well flanked and commanded from the Body of the Place, and will hold out nearly as long, with its Ditch on a Level with the Surface of the Water, as if it were carried down to 6 or 7 Feet below the Surface; ſuch a narrow wet Ditch being eaſily, and ſoon filled up; and the Time taken up in filling it, will by no means be equivalent to the Expence of digging it, and feveting its Eſcarp and Counterſcarp.

119. The Baſtion of this Method, if it is not reveted, will be leſs expenſive than the common Baſtion; and very little more, if it is reveted, including alſo the Expence of the low Demi-lune. But if the Baſtion only is reveted, and not the Demi-lune, the Expence, in that Caſe, will be rather leſs than of a common Baſtion alſo reveted, ſince the Ditch of the ſaliant Front is only 10 Feet under the Level of the Field. If this Method is conſtructed with a dry Ditch, the low Demi-lune muſt be continued to the Baſtion, without any intermediate Ditch. This Method may be alſo conſtructed without the Demi-lunes, the ſpace which they occupy being razed almoſt even with the Surface of the Water: In that Caſe, other Advantages will ariſe, in lieu of thoſe which the Demi-lune afforded, without any of the Diſadvantages of this Piece (126); and the Conſtruction will then be ſtronger, I imagine, in Proportion to the Expence of it; as it will alſo be more ſimple.

CHAP. XI.

Of the Defences of the Fifth Method.

120. THIS Method, Pl. VII. has the fronted Baſtions of the preceding; and is reinforced with a Counterguard, of a particular Conſtruction, before each Baſtion, which, from its Reſemblance to a Crownwork, may be properly enough termed a Crown-counterguard; and with great Lunettes in the covered Way. The Expence of it is, indeed, conſiderable; but ſtill more ſo its Strength, which is obtained in this Syſtem in an eminent Degree.

121. The Creſt of the Breaſtwork of the great Lunettes of the covered Way is 12 Feet above, and the Bottoms of their Ditches are 4 Feet under the Level of the Field. The Crown-counterguard is 15 Feet high, and its Ditch 12 Feet deep. The Space L, before the Front of the Baſtion, is razed even with the Surface of the Water, or within a Foot of it; and the Water is ſuppoſed to be within 4 Feet of the Surface of the Field. The Heights of the other Works, and the Depths of their Ditches, are the ſame as in the preceding Method.

122. I have in this, as in the foregoing Methods, had principal Regard towards commanding, as much as poſſible, the great Ditch, and its Counterſcarp; and the Outworks, their Ditches, and Counterſcarps; and the Glacis. The Lunettes command well the covered Way, the Glacis, and the Field; and are well flanked and commanded by the Crown-counterguards, and Ravelins.

123. The

123. The Crown-counterguard, H H, commands well the Field; and alſo the Lunettes, their Ditches, and covered Way, and Glacis; and contributes, with the Faces of the collateral Ravelins, to flank extremely well its proper Ditch, and Counterſcarp: The Space S, for raiſing a Counterbattery on, againſt the Defences of that Ditch of the Counterguard, is commanded by a Front vaſtly ſuperior, as is indicated by the pointed Lines: The inclining Shoulders (H) of this Piece, which are nearly perpendicular to the covered Way of the Ravelins, flank well that covered Way, and alſo bear againſt the Ditch of the Ravelin (Z), in a pretty direct manner, and againſt the Face of the Ravelin in reverſe. This Piece is alſo commanded, in the moſt effectual manner, by the whole Front and long Faces of the Baſtion B, which it covers; by the Flanks of the collateral Baſtions; by the collateral Ravelins, and the Flanks of their Redouts; and obliquely from the collateral Curtains: So that it ſeems to have all the Advantages and Properties, that can be expected or deſired in an Outwork.

124. Perhaps it may be objected to this Work, that the Beſiegers, to evade the great Fire which bears upon its Ditch, will firſt make themſelves Maſters of the two Lunettes, and the Ravelin of the Front attacked; and afterwards carry Paſſages over its Ditch to the Extremities H, H, of its inflected Shoulders, which will not then be ſeen from any defenſive Work. I am ſo far from thinking this Objection of any Weight, that I am of Opinion, it will be moſt advantageous for the Beſiegers, to begin by making themſelves Maſters of the Baſtion F of the Crown-counterguard, by reaſon the Lunettes K K are commanded in the ſtrongeſt manner by the Counterguard; and ſome Part

of

of the Lodgement of the Enemy, on the Creſt of the Glacis of theſe Lunettes, on the Side of the Baſtion F of the Counterguard, will be ſeen in reverſe from the ſaliant Angle of this Piece. If any one, nevertheleſs, ſhould entertain ſome Diſtruſt of this Conſtruction of the Shoulder of the Crown-counterguard, it may be inclined more inwards till it is flanked from the Curtain, as that of the Counterguard P, taking away at the ſame time the low Flank of the Shoulder, and then the whole Ditch of the Crown-counterguard will be ſeen from its proper Flanks and the Curtain together: But for my Particular, I prefer the former Poſition of the Shoulders, becauſe they command better the Lunettes, and are more commanded by the Ravelins; and the low Flanks are alſo of good Uſe.

125. It is affirmed in Mr. Vauban's Book of the Attack, that if a Baſtion is covered by a Hornwork, the Beſiegers muſt be obliged, in their Attack of that Baſtion, to reduce not only the Hornwork, but alſo the two collateral Ravelins, before they can be Maſters of it; but if the Hornwork is large, and terminates on the Counterſcarp of the great Ditch, as thoſe exhibited in Plates 20. and 21. of Mr. Vauban's Book, I ſuſpect there is a Poſſibility of taking the Baſtion thus covered, without reducing one of the collateral Ravelins, eſpecially in Fronts above 160 Toiſes; becauſe theſe Ravelins may be wholly commanded from the long Wings of the Hornwork, and by the Help of the Ricochet and Shells; and the Counterſcarp of the great Ditch within the Gorge of the Hornwork, is almoſt wholly covered, from the Fire of the Flanks of the collateral Ravelins, by the interior Extremities of the Wings or long Sides of this Piece, and affords ſufficient room for raiſing Batteries to batter in Breach,

and to command the oppoſing Flanks; and this capacious Work is badly commanded, and eaſily lodged on; and the Enemy's Lodgements thereon are quite ſecure from Sorties, which can only attack them in the Front contained within the Gorge of this Hornwork. But I think it is pretty evident, that the Beſiegers, before they can take one of the Baſtions, ſuppoſe B, of this Method, and before they can be wholly Maſters of the Crown-counterguard, which covers it, muſt neceſſarily take the two collateral Ravelins D, Z, together with their Redouts; for the Reaſons mentioned in the foregoing Chapter (114): For the Crown-counterguard is well flanked by the Faces of the collateral Ravelins, and almoſt wholly ſeen from the Flanks of their Redouts. But if the Beſiegers are obliged to take the two collateral Ravelins, they muſt alſo take the four collateral Lunettes (104). Conſequently the Beſiegers, before they can reduce one Baſtion, muſt, if they carry on their Attack regularly, take one Crown-counterguard, four Lunettes, and two Ravelins and their Redouts; which together with the Baſtion amount to eight Pieces, excluſive of the Redouts of the Ravelins: And if they attack two Baſtions, they muſt take two Crown-counterguards, ſix Lunettes, three Ravelins and their Redouts, and two Baſtions; which are 13 Pieces, excluſive of the Redouts of the Ravelins; and the Conqueſt of theſe Works muſt be attended with the utmoſt Difficulty, and an immenſe Expence of Shells, on account of the Superiority of the commanding Fronts, and the great Number of Works which muſt be taken; and the Siege will therefore be remarkably long and fatal to the Enemy.

126. The Space L before the Front of the Baſtion, has no Breaſtwork, as in the preceding Method; becauſe the

Crown-counterguard, by being ſo high above it, would command its Terreplain, and render it of little Uſe: But, by its being thus razed, it is attended with other Advantages which, perhaps, ballance thoſe attending the Demilune of the preceding Method. The Aggreſſors, if they puſh their Attack, and Paſſage of the great Ditch towards the ſaliant Front of the Baſtion, will, when they arrive at this low Ground, have no Earth for eſtabliſhing a Lodgement in it, or for puſhing a direct Sap a-croſs it; and it will be wholly commanded, and alſo the continuous great Ditch, by the whole Front of the Baſtion, by ſome Part of the great high Flanks of the collateral Baſtions, and the Flanks of the Redouts of the collateral Ravelins; whereas, in the preceding Method, the Breaſtwork of the Demilune, intercepts, in a great meaſure, the Fire of theſe Works from ſome Part of the great Ditch, before the Faces of the ſaid Demilune.

CHAP. XII.

Of the Defences of the ſixth Method.

127. THIS Method, Pl. VIII. with detached Baſtions, has all the Works powerfully and directly flanked; and the exterior Works are ſtrongly commanded by the interior. The Body of the Place has the Creſt of its Breaſtwork 20 Feet high above the Level of the Field; the Redout (C) of the detached Baſtion 15 Feet; the detached Baſtion 18, and the double Tenaille (F) ſeven. The Ravelin has its Creſt 16 Feet high at the ſaliant Angle, and 15 at the Flanks and interior Extremities of the Faces; and its

Redout is 12 Feet high. The Lunettes are 12 Feet, and the Creſt of the Glacis ſix above the Level of the Field. The Depth of the Ditch of the Baſtions and Curtains of the Place, included within the Gorges of the detached Baſtions and the collateral Faces of the double Tenailles, is 10 Feet under the Level of the Field; and the Ditch of the Redout of the detached Baſtion three Feet. The great Ditch, and the Ditches of the other Works, are the ſame as in the preceding Method.

128. The Lunettes are ſmall, to moderate in ſome meaſure the great Expence that muſt needs attend the Execution of this Method, but they are exceedingly well flanked and commanded, and capable of making a good Defence.

129. The Flanks of the Ravelin are made perpendicular to the Counterſcarp of the great Ditch, which therefore they defend well; and by making a larger Angle with the Face of the Ravelin, than if they were made parallel to the Capital, the Inſide of the Breaſtwork of that Face comes to be flanked more directly from the convex Portion of the Flank of the detached Baſtion, and from the Curtain. The Redout of the Ravelin is large and well flanked, and contributes as thoſe of the preceding Methods, to command the Ravelin, and, by means of its Flanks, the collateral and interior Works. The Ravelin and its Redout are commanded by the Flanks of the detached Baſtions, and by one Baſtion, two Curtains, and two Flanks of the Place. The great Ditch and its Counterſcarp (P), are moſt powerfully commanded by an exceeding large Front, as is indicated by the pointed Lines; and the Body of the Place is admirably well flanked, greatly ſuperior to that of any former Method with detached Baſtions.

130. Where the Water is within three or four Feet of the Surface, the Terreplain of the detached Baſtion may be cut down within a Foot of its Level, at the interior Margin of the Gorge, and from thence may be made to riſe in Glacis to the Level of the Field. The pointed Lines x x, mark out a Retrenchment which may be made in the detached Baſtion, on the Breaſtwork and Terreplain of the Rampart, and interior Slope of the latter, by Way of a Coffre, or interred Lodgement; and on the low Terreplain, with a Breaſtwork and dry Ditch. The detached Baſtion is commanded by one Baſtion, two Curtains, and two Flanks of the Place. The Redout c of the Baſtion is well flanked and commanded, and may make a good Defence; it alſo covers the Flanks of the collateral Baſtions of the Place, which defend the Paſſage of the Ditch before the Faces of the oppoſite and interior Baſtion B; and the Enemy will be obliged to raze its Breaſtwork before they can ſilence one of theſe Flanks by a Counterbattery, for it is not practicable to raiſe a Battery in the Redout; becauſe it is ſo ſmall and ſo much commanded.

131. The double Tenaille (F), in the great Ditch, contains a great deal of Fire, and is convenient for Muſqueteers for defending the great Moat, and the Breach of the Baſtion; it has an eaſy Communication with the Place, and contributes to render the Communication with the Ravelin leſs difficult.

CHAP. XIII.

Of the Defences of the ſeventh Method.

132. THE ſeventh Method, Pl. IX. Fig. 1. is pretty ſimple; its Expence will be ſmall, and the Strength thereof conſiderable in proportion to its Expence. The Enceinte of exterior Works which ſhew as ſo many Counterguards and Lunettes, is no more than the covered Way, which is ſuppoſed to be raiſed three Feet above the Level of the Field, cut off with three Toiſes of its Breaſt-work from the Glacis; and the inward from the ſaliant Places of Arms, by a narrow and ſhallow Ditch.

133. The Height of the Breaſtwork of the Faces and Flanks of the Baſtion, and of the Curtain, is 19 Feet above the Level of the Field, the Ravelin 15; and the Creſts of the Breaſtworks of the ſeveral Pieces of the covered Way 9; and that of the Glacis 5. The Depth of the great Ditch is 15 Feet, that of the Ravelin 12; and the Ditches of the Lunettes of the covered Way, are 3 Feet under the Surface of the Field, or on a Level with the ſubterraneous Water; and thoſe of the Counterguards, or ſaliant Places of Arms, are within 2 Feet of the Surface of the Water, or 1 Foot under the Level of the Field.

134. In this Method the Glacis and the Field are well commanded by the Faces of the detached Pieces of the covered Way; which Pieces are very little expoſed to the Field-batteries of the Enemy; and the Faces of the Baſtions and Ravelins are well covered from the Field, and flank and command well the Pieces of the covered Way.

135. The ſaliant Places of Arms, or Counterguards of the Baſtions and Ravelins, are well flanked by the Lunettes, or inward Places of Arms; and the latter in the ſtrongeſt manner by the Baſtions and Ravelins; by which means there are no dead Angles, and the Conqueſt of the Lunettes will be extremely difficult; nor will the Beſiegers be able to compleat their Lodgements on the Counterguards, until they are Maſters of theſe Lunettes: They will alſo be under a Neceſſity of taking the two collateral Lunettes, becauſe they may then, and not before, being ſecure from Sorties, fill up the Ditches of the collateral Faces of the Counterguards (B) of the Baſtions attacked, which will ſerve as Platforms, and the Breaſtworks of theſe Faces as Epaulments for their Batteries againſt the Flanks of the Demibaſtions of the Front attacked; which will not, however, be of equal Extent, or contain ſo many Cannon as theſe Flanks. And the Enemy may in this alſo be diſappointed, by deſtroying the Breaſtworks of theſe Counterguards by Fougaſſes, when the Beſieged are obliged to abandon them: The Ditches of the Counterguards may have Traverſes in their interior Extremities; as the one exhibited in the Profile, Fig. 2.

CHAP. XIV.

A Detail of the Defences of the eighth Method: To which is ſubjoined, an extenſive View of the Principles and Reaſons which ſerve to determine the beſt Lengths of defenſive Fronts, conſtructed with Ravelins, or with Ravelins and Counterguards, or wholly ſimple, for Circumferences of different Diameters: Together with a general Idea of the Degrees of Strength of regular Enceintes of different Conſtructions, but equal Diameters, with reſpect to one another, and to their reſpective Expences, and Simplicity of Conſtruction.

136. FROM the ſubſequent Demonſtration of the Strength of each of the ſeveral Fronts of the Portion of an irregular ravelined Enceinte, exhibited in Pl. XI. (143), and from the Conſtruction thereof, it may be obſerved, that in narrow ravelined Fronts betwixt 140 and 160 Toiſes, the more ſaliant the Ravelins are in reſpect of the Baſtions, and the more extended their Demigorges in proportion to the Length of the exterior Side, provided their Capitals do not exceed 48 Toiſes, and that their Faces are not flanked too obliquely, the ſtronger will theſe Fronts be; and the contrary.

137. On theſe Principles (136) may be formed an excellent ravelined Syſtem, which is repreſented by Fig. 3. Pl. IX. The exterior Side of the Dodecagon upon which this Specimen is conſtructed, is only 140 Toiſes; the Perpendicular is 30; the Face of the Baſtion 43; the ſtraight high Flank of the Baſtion is perpendicular to the Line of

Defence, and reinforced by a Flank of the Gorge (4). The Breadth of the great Ditch at the ſaliant Angle is 15 Toiſes; the Length of the Capital of the Ravelin 48; its Flank 5; and its Face is directed to the Face of the Baſtion at 10 Toiſes above the Angle of the Shoulder, and is terminated by the Production of the Counterſcarp of the great Ditch, which diverges from the Face of the Baſtion, and is directed to the outward Extremity of the Flank of the Ravelin. The Heights of the ſeveral Works are the ſame as thoſe of the ſecond Method, except the ſtraight Flank of the Ravelin, which is only 12 Feet high.

138. The Ravelin of this Method is productive of all the Advantages which attend the Ravelins of Bergenopzoome; beſides the following ones: To the Flanks thereof, the great Ditch is wholly and directly expoſed, by reaſon they project 5 Toiſes within the Direction of the Counterſcarp of the great Ditch: Theſe Flanks are alſo retired at a good Diſtance from the Faces of the Ravelin, without making their Breaſtworks continuous to thoſe of the Faces; by which means the Footbank and Terreplain of the Rampart of theſe Faces of the Ravelin come to be ſeen in Flank, and moſt powerfully commanded from the Shoulders of the Baſtions; which is of the utmoſt Importance: A Space about 3 Toiſes in Breadth, within the Rampart of the Ravelin, is alſo ſeen from the Baſtion, without any Interruption; and is intended for the Ditch of a Retrenchment or Redout, which may be thrown up occaſionally in the Ravelin, as the one diſtinguiſhed by the pointed Lines in the Ravelin A, it will then reſemble the Redouts of the preceding Methods, and be well flanked and defended by the interior Works, and have a good Effect; and ſuch a

Redout may be ſpeedily executed, ſince its Flanks are always ready made.

139. The Ravelins of this Conſtruction (137), ſince they are ſo ſaliant, with reſpect to the Baſtions, and at ſo ſmall a Diſtance from each other; and their Demigorges ſo long, in reſpect of the Length of the exterior Side, will oppoſe an almoſt invincible Reſiſtance to the Advances of the Enemy's Sap to the ſaliant Angles of the covered Way, before the Angles of the Baſtions attacked; and occaſion their Lodgements and Batteries to be eſtabliſhed on the covered Way and Creſt of the Glacis before theſe Baſtions, with the utmoſt Difficulty and Danger; inſomuch that the Beſiegers will be under a Neceſſity, if the Defence is good, of reducing, not only the Ravelin of the Front attacked, but alſo the two collateral ones, before they can perfect theſe Lodgements and Batteries; the Ravelin having, in this Method, Pl. IX. Fig. 3. the ſame Effect as the great Lunettes of Bergenopzoome (10, 11.); and theſe Advantages (139) are obtained in a greater or leſs degree, according as the Angles of the exterior Sides are more or leſs open: And tho' we ſhould ſuppoſe a Poſſibility of taking two of its Baſtions, without taking the collateral Ravelins, yet the Defence of the Front attacked, by means of the collateral Ravelins, and the Time gained thereby will be very conſiderable; and the Aggreſſors will ſtill be obliged to take the Ravelin of the Front attacked, before they can eſtabliſh their Lodgements and Batteries before the Demibaſtions of that Front; the Ravelin having, in this Caſe, on account of the Proximity of its Faces to the oppoſite ſaliant Angles of the covered Way, the ſame Effect as the great Lunettes abovementioned: It is for this Reaſon that I give no Tra-

verſes to the covered Way of the Baſtions of this Conſtruction; and alſo that it may be more expoſed to the Flanks of the Baſtions, and to the oblique Fire of the Curtain: Temporary Traverſes, however, may be therein raiſed, if found neceſſary. But the Baſtion being much higher than the Ravelin, will bear into the covered Way of the latter over the Creſt of its Traverſe. The Ravelin is commanded in the moſt efficacious manner by the Faces of the Baſtions, which it alſo covers, in ſome meaſure, from the Field.

140. The only Objection this Conſtruction ſeems liable to is, that the Aggreſſors may, perhaps, content themſelves with battering in Breach the Face of the Baſtion, from the Creſt of the Glacis before the ſaliant Angle of the Ravelin; from thence, however, it will be very difficult to accompliſh a mountable Breach, on account of the Wideneſs of the Diſtance *; and their breaching Battery ſo ſituated, will be expoſed to a powerful Reſiſtance from the Face of the Baſtion againſt which it is directed; beſides, the Beſiegers will be obliged to carry over their Paſſage of the great Ditch to the Shoulders of the Baſtion, which will therefore be wholly ſubjected to the Command of the Fire of the oppoſite Flank of the Place; and alſo to the oblique Fire of

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* In the late Siege of Bergenopzoome, the two Batteries on the Creſt of the Glacis before the ſaliant Angle of the Ravelin attacked, conſiſting each of 3 Pieces of Cannon which battered in Breach, during 4 ſucceſſive Days, the Faces of the oppoſite Orillons of the Baſtions, had but a very inconſiderable Effect, notwithſtanding the Diſtance was not great; the Ravelin being ſmall, its Capital ſhort, and the Ditches narrow; and altho' the Battery which was directed againſt the right Orillon of the Baſtion Pucelle, fired without any Interruption; the defenſive Battery of the Face of this Orillon having been neglected and abandoned by the Beſieged; and the Battery againſt the Orillon of the Baſtion Coehorn met with very little Reſiſtance from its oppoſing Battery, which fired ſeldom, and was wholly ſilenced on the ſecond Day.

the Curtain, if the Ditch is wet; and it will be greatly expoſed to Sallies,and other Chicanery,if the Ditch is dry; and the Screen of the Paſſage of the Ditch muſt be raiſed to a greater Height, on account of its Proximity to the oppoſite high Flank; ſo that the Enemy will ſcarce ſucceed, by conducting their Attack in this manner, if the Defence is good: But even ſuppoſing the Beſiegers do carry on their Attack ſucceſsfully in this manner, their Batteries on the Creſt of the Glacis againſt the Flanks of the Baſtions attacked, will ſtill be commanded by the collateral Ravelins, which they will be under a Neceſſity of reducing, or of commanding by high Epaulments and Lodgements, extremely difficult and dangerous to be executed, and by a continual Fire of the Ricochet and Shells. That this Inconvenience however, if it can be deemed one, may be entirely prevented; the Ditch of the Ravelin may be made 3 Feet deep only, with a Breadth of four or five Toiſes, after the manner of Mr. Coehorn's Lunettes; the Dimenſions and Conſtruction of it being otherways the ſame as above ſpecified (137, 138.). This Ravelin with a ſhallow Ditch will have nearly all the Advantages we have aſcribed to the former (138, 139.), and be conſtructed at a much leſs Expence; it is liable indeed to have Galleries more eaſily carried in under its Ditch, if the Ground is high above the Level of the ſubterraneous Water; neither can it in that Caſe have any Loop-holed Gallery in the Wall of its Counterſcarp: There may be, nevertheleſs, a ſubterraneous one under its covered Way, or Ditch, to puſh Countermines from occaſionally; and vertical Pits may be made from thence, to intercept any Gallery which the Aggreſſors may attempt to carry in near the Surface. From what is ſaid then it appears,that this Method(137) is excellent either with a deep Ditch to the Ravelin, or with a ſhallow one; but that it will be ſtronger in proportion to the Expence with ſhallow ditched Ravelins, than with deep ditched ones.

141. If the Fronts of this Conſtruction, Pl. IX. Fig. 3. are ſuppoſed to be contracted each to 120 Toiſes, the Angles of the Polygon being ſtill the ſame, and the Ravelins of the ſame Dimenſions, the Force of their mutual Defence of each other will, in that Caſe, be conſiderably augmented, and it will be impracticable to reduce two Baſtions, without firſt taking three Ravelins, if the Defence is tolerable; but then the Baſtions will be too ſmall; their ſaliant Angles will be leſs open than thoſe of the former, and the Curtain of leſs Extent, and rather too ſhort; and the Expence of a Series of theſe Fronts will be greater than the Expence of one of equal Extent, of the former of 140 Toiſes. Again, if we ſuppoſe the Fronts of this Conſtruction, Pl. IX. Fig. 3. to be extended ſo as to meaſure about 160 Toiſes each, the Ravelins being ſtill of the ſame Form and Dimenſions as in this Figure, and the exterior Angles alſo the ſame; it is evident, that the Efficacy of the mutual Defence of the Fronts will then be conſiderably diminiſhed, and the commanding Power of the Front attacked will be much abated (39, 41.). In this the Ravelin is commanded chiefly from the Curtain, and therefore with leſs Power; but in the former, moſt efficaciouſly by the Faces and Shoulders of the Baſtions (138). In this the Baſtions indeed will be larger, and their flanked Angles opener; but theſe Advantages will by no means be equivalent to the Diſadvantages the Fronts incur in this Caſe, in conſequence of their being extended to 160 Toiſes; nor

can theſe Diſadvantages be remedied in any conſiderable degree, by extending the Capital of the Ravelin above 48 Toiſes, and its Demigorges proportionably; becauſe it will then become too ſaliant, and be more eaſily approached by the Beſiegers, and much leſs commanded by the Place (40). Upon the whole then (136 to 141), I am of Opinion, that a regular Series of ravelined Fronts, conſtructed in the manner abovementioned (137, 138.), on a right Line of any determinate Length, or upon Sides inſcribed within a curve one, whoſe Angles are not inferior to thoſe of an Enneagon, and conſiſting of about 140 Toiſes each Front, having a little leſs or more Extent, according as the exterior Angles are greater than thoſe of an Enneagon, or approach nearer thereto: Such a Series, I ſay, will have more abſolute Strength, than a ſtraight or curve Series of equal Extent of ravelined Fronts, which are greater or leſs, in any conſiderable degree, than 140 Toiſes each; and be alſo ſtronger in proportion to the Expence of its Conſtruction, provided that the Fronts of this laſt curve Series are inſcribed in a Segment of the ſame Convexity with the one which circumſcribes the former Series wherewith it ſtands in Competition.

142. In Polygons under an Enneagon, the Fronts muſt be more extended, and that in a certain meaſure alſo more or leſs, as the Angle of the Polygon is more or leſs open; that the Baſtions, in narrow-angled Polygons, may not be too ſmall, and their ſaliant Angles too acute; and alſo becauſe the Fronts derive leſs Aid from the collateral ones, as the exterior Angles are leſs open: Therefore the beſt Length of Front for a ravelined Hexagon with common Baſtions, ſeems to be about 150 Toiſes; the Ravelin having its De-

migorges extended ſo as to cover 11 Toiſes of each of the Faces of the oppoſite Demibaſtions, with a Capital of 48 Toiſes, and with Flanks as above ſpecified (138). But if a ravelined Hexagon is to be conſtructed with fronted Baſtions, according to the fourth Method, the beſt Length of an exterior Side will be 160 Toiſes, or nearly ſo. The beſt Length alſo for the Fronts of a ravelined Pentagon with common Baſtions, will be about 160 Toiſes. What is ſaid with regard to ravelined Fronts will alſo hold good in Fronts that are conſtructed with Ravelins and ſimple Counterguards.

143. Now if we ſuppoſe two Towns, the Radius of the Circumference of each of which is 200 Toiſes, to be fortified, the one with ravelined Fronts of 137 Toiſes, according to the Conſtruction laſt exhibited (137); and the other, with ravelined Fronts of 200 Toiſes, the former being an Enneagon, and the latter a Hexagon; it is evident that the whole Strength of a Front of the former Enceinte, according to the Method we obſerve in computing the ſucceeding Eſtimates (Ch. 1. Sect. 3.), will amount to about 51 Days; *viz.* 9 Days for each of the three Ravelins, which the Aggreſſors are ſuppoſed to be under a Neceſſity of taking (139), and 24 Days for the two Baſtions; and that the Strength of a Front of the latter, which is a Hexagon, will not amount to above 28 Days at moſt, allowing for the two Baſtions attacked 18 Days; and 8 for the Ravelin; and 2 Days in conſequence of the Aid which this laſt Piece derives from the collateral Ravelins; conſequently the Strength of the former will exceed that of the latter by 23 Days. But as the Expence of the Enneagon will be alſo greater than that of the Hexagon, tho' they are both inſcribed in Circles of equal Diameters, we ſhall ſuppoſe the

Fronts of this latter to be reinforced by pretty large Lunettes in the covered Way, which, as I conceive, will raiſe the Expence of it conſiderably above that of the ſhort fronted ravelined Enneagon; ſince its Baſtions and Ravelins, tho' fewer in Number, muſt be larger than thoſe of the Enneagon (36, 37.). Now the Strength of the long fronted Hexagon thus fortified, will amount to about 43 Days, allowing 5 Days for each of the two Lunettes of the Front attacked, for they will amount to no more in this long Front of 200 Toiſes (41), and 5 Days of borrowed Force from the collateral Lunettes; for the Enemy will not be under any Neceſſity of taking them (179); which is ſtill 8 Days inferior to the Strength of a Front of the Enneagon. It may be objected, perhaps, to this Eſtimate, that there is a Poſſibility of taking two adjacent Baſtions of the ravelined Enneagon, without reducing the two collateral Ravelins; granting this to be true, the leaſt we can allow in this Conſtruction for the borrowed Force which theſe collateral Ravelins yield to the Front attacked, is 10 Days; which added to 33 Days, the proper Strength of the ſhort open angled Front, will give 43 Days for the whole Strength of this Front; which is ſtill equal to the Force of the long Front of the ravelined Hexagon, tho' reinforced with great Lunettes in the covered Way. The ſhort fronted Enneagon then will have a higher degree of Strength, in proportion to the Expence of it, and much greater Simplicity, in proportion to its Strength, than the long fronted ravelined Hexagon, when reinforced with great Lunettes in the covered Way; to which it is therefore greatly preferable.

144. Again, if we ſuppoſe an Octagon inſcribed in a Circle of the ſame Diameter with that which circumſcribes

the ravelined Enneagon (143), its Sides being each 55 Toiſes, and fortified with Ravelins and great Lunettes in the covered Way; and compare it in point of Strength with the preceding ravelined Enneagon, it will be found that the Strength of each will bear the ſame Proportion nearly to their reſpective Expences, even tho' we ſuppoſe that the Aggreſſors are not under any neceſſity of taking the two Ravelins collateral to the Front attacked of the Enneagon; but if theſe Ravelins muſt be taken, the Aſcendant will be conſiderably in favour of the ravelined Enneagon; which will, therefore, be alſo more ſimple, in proportion to its Strength, than the Octagon with Ravelins, and great Lunettes in the covered Way.

145. But if we ſuppoſe the ravelined Enneagon, whoſe Fronts conſiſt of 137 Toiſes each, to be compared in point of Strength to a regular ravelined Enceinte of equal Circumference, conſtructed according to the fourth Method; Pl. VI. its Front, or exterior Side being 160 Toiſes, or nearly ſo; we ſhall find, that this latter will be much ſtronger, in proportion to the Expence that will attend the Execution of it, than the former ravelined Enneagon (143): It will have as much abſolute Strength, at leaſt; ſince any one of its Fronts derives not only as much borrowed Force from the collateral Fronts as a Front of the Enneagon, but has alſo a greater Share of proper Strength, its length being 160 Toiſes (45, 48); and the Aggreſſors muſt alſo be under a Neceſſity of reducing three Ravelins before they can make themſelves Maſters of two of its Baſtions (Chap. 10.): Beſides, it will be a great deal leſs expenſive than the ravelined Enneagon, becauſe its Fronts are longer, and the Number of its Baſtions and Ravelins, conſequently fewer; and becauſe the

Demigorges of its Ravelins will be leſs extenſive, and its Baſtions not more chargeable than thoſe of the Enneagon; conſequently, its Simplicity is likewiſe greater, in proportion to its Strength.

146. The Strength of the fifth Method will likewiſe increaſe in the ſame proportion nearly, with reſpect to the Expence of its Conſtruction, as that of the fourth Method; becauſe it has all the Advantages of the fourth Method; and the Reinforcement which it acquires, by means of the Crown-counterguard, and the great Lunettes in the covered Way, is remarkably great, in proportion to the Expence of theſe Works.

147. If the ſhort-fronted Enneagon (143) is reinforced by ſimple Counterguards, it will acquire, by means thereof, a very conſiderable Increment of Strength, becauſe theſe Counterguards will be cloſely and moſt powerfully commanded by the Ravelins, and in a great degree alſo from the Place; and they will occaſion, in theſe ſhort Fronts, an inevitable Neceſſity of reducing the collateral Ravelins of the Front attacked (139). Therefore, the Strength of this Conſtruction (143) will be thereby augmented, in a pretty conſiderable Proportion, with reſpect to the Expence of theſe additional Pieces.

148. But as the great defenſive Power of ſhort open angled ravelined Fronts, ſprings chiefly from their mutual Defence, by means of the Ravelins; and the powerful Command which theſe Pieces have over the Creſt of the Glacis and covered Way before the Baſtions; and the Baſtions over the Ravelins; ſo the Strength of ſimple and unravelined Fronts will be much leſs, in proportion to their Expence, than that of the ravelined ones; nor will that Strength be

augmented, in ſo great a meaſure, in the ſimple, as in the ravelined Fronts, as the outward Sides are ſhortened, and their Angles enlarged (150). I am, therefore, of Opinion, that a Series of ſimple Fronts conſtructed on the Sides of a Dodecagon, or on a ſtraight Line, will be ſtronger, in proportion to the Expence, at about 150 Toiſes each, than a Series of equal Extent of ſimple Fronts that are greater or leſs in any conſiderable degree than 150 Toiſes (141, 142.); and alſo that a Series of ſimple Fronts, whoſe exterior Angles are ſimilar to thoſe of a Hexagon, will be ſtronger, in proportion to the Expence, at 160 Toiſes each Front, than with Fronts of a much greater or leſs Extent; provided alſo that theſe Fronts have their Perpendiculars and Faces of the Baſtions, and the Poſition of their Flanks, determined by the Rules and Principles which are exhibited in the foregoing (70, 71, 72.). In ſimple defenſive Fronts, the Counterſcarp ſhould be directed to the Flank of the Baſtion at four or five Toiſes from the Angle of the Shoulder, that the Lodgement of the Enemy on the covered Way may be flanked directly from the Shoulder of the Baſtion, and that their Lodgement on the Creſt of the Glacis may be expoſed as much as poſſible in Flank to the Fire of the Face of the Baſtion.

149. But it will frequently happen, that a Place ſhall be required to be fortified, the Importance whereof, will not be equal to the Expence of fortifying it with an Enceinte of the ſtrongeſt ſimple Fronts its Circumference is ſuſceptible of, or that the Sum allowed for raiſing and perfecting the Fortification, ſhall not be ſufficient for the Execution of ſuch a Plan: In ſuch a Caſe, the Fronts muſt be ex-

tended, and the Number of Baſtions in the Enceinte, conſequently, diminiſhed; and the Face of the Baſtion muſt be made ſhorter, and alſo the Perpendicular, in proportion to the Length of the exterior Side, ſo as to make the Expence quadrate with the Importance of the Place, or Sum that may be allowed for executing the Deſign. Mr. Vauban has deſigned his firſt Method with longer Fronts and ſmaller Baſtions, in proportion to the Length of the exterior Side, than thoſe of our Methods; not that it might be the ſtrongeſt ravelined Incloſure that can be raiſed on any particular Circumference, but that it might be practicable at a moderate Expence. But I think it is pretty evident, from what is already ſaid in this ſecond Section, and particularly in the firſt and 14th Chapters thereof, that by contracting the Fronts to a certain meaſure, as we have directed; and, conſequently, increaſing the Number of Baſtions, and enlarging their Angles, and making them as ſpacious, in reſpect of the exterior Side, as is conſiſtent with other Conſiderations; and by giving the Ravelins very extenſive Gorges, and long Capitals, in proportion to the Lengths of the Fronts, but ſo as to be directly enough flanked by the Baſtions, and not to exceed 48 Toiſes in the Length of the Capital; by ſo doing, I ſay, it is pretty evident, that the Strength of the Fronts will increaſe, in a greater proportion, than the Expence that will be found to attend the Execution of them: The ſtrongeſt ravelined Fronts then will alſo be the ſtrongeſt in proportion to the Expence of their Conſtruction. Therefore, the ſtrongeſt and moſt perfect ravelined Conſtructions ought always to be preferred to weaker and leſs expenſive ones, provided the Place to be fortified is of ſo much Importance to the State;

and that the neceſſary annual Sums for carrying on the Work, may be conveniently ſpared out of the Revenues of the Prince whoſe Property it is.

150. I am of Opinion, that the ſtrongeſt and moſt perfect ravelined Enceinte (141), is ſtronger, in proportion to the Expence of it, than the ſtrongeſt and moſt perfect ſimple one (148); and that it is more or leſs ſo according as the Angle of the Polygon is more or leſs open; for the Front A, B, Pl. XI. acquires a Degree of Strength, by means of its Ravelin and the collateral ones, that is equal to $\frac{2}{3}$ nearly of the whole Strength of that Front ſimple, without the Ravelins; and the Front D E, an additional Force that exceeds $\frac{1}{2}$ of its Strength ſimple, in conſequence of the Ravelins; altho' the whole Expence of the Ravelins of this Figure, Pl. XI. will be ſcarce equal to $\frac{1}{3}$ of the whole Expence of the ſimple Fronts thereof, excluſive of the Ravelins. I am likewiſe of Opinion, that the ſtrongeſt ſimple fronted Enceinte (148), will be inferior in Strength to a ravelined Enceinte of judicious Conſtruction, raiſed on the ſame Circumference, at the ſame Expence: The Ravelins in this Caſe being made with low Ramparts and ſhallow Ditches, after the manner of Mr. Coehorn's Lunettes; and the Fronts being extended, and the Faces of the Baſtions, and the Perpendicular ſhortened, until the Expence of the Enceinte comes to quadrate with that of the ſtrongeſt ſimple-fronted Enceinte; becauſe the Ravelins by their powerful Command of the great Ditch, the covered Way, the Glacis and the Field, and their mutual Defence of each other, and by their being ſo effectually commanded by the Body of the Place, augment greatly the Strength of an Enceinte, as we have already obſerved (150). Hence it appears,

pears, that the ſtrongeſt ſimple Fronts (148), ought never to be practiſed, ſince the Sum that is neceſſary to the Execution of the Deſign will be ſufficient for raiſing a ravelined Enceinte of greater Strength, and equal Circumference.

151. From what is ſaid then, in this Chapter, and in the firſt one of this Section, it appears, that the moſt advantageous Length of a defenſive Front is different, not only in different regular Circumferences, but alſo in Syſtems of different Conſtructions applied to regular Circumferences of equal Diameters; and that the Method of Fortification, whoſe principal Outworks conſiſt of Ravelins, and great Lunettes in the covered Way, is ſubject to leſs Variation in the Length of its Fronts, in different Circles, than any defenſive Syſtem that is leſs complex; becauſe the ſeveral Works thereof, when formed of the juſteſt and moſt advantageous Magnitudes, and ſuſceptible of the beſt Defence, juſt fill up an Extent of 160 Toiſes, ſo as to occaſion the Lines of the flanking Defences of the Body of the Place, and of the ſeveral Outworks to be very ſhort, and their Fire, by conſequence, exceedingly efficacious; and their Command of each other, and of the covered Way and Glacis, eminently powerful; conſequently, the proper Force of a Front of 160 Toiſes thus conſtructed, will not only be very great, but alſo the borrowed Force which it derives from its ſimilar collateral Fronts; and the Meaſure of the borrowed Force will be very conſiderable in ſmall as well as in great Enceintes: Therefore, the beſt Length of Front for this Syſtem with Ravelins and great Lunettes in the covered Way, will be about 160 Toiſes, or very little more or leſs, whether it be conſtructed on a ſmall or very great Circumference, or on a right Line. It is alſo evident,

from what is ſaid in the foregoing, that the ſtrongeſt ravelined Fronts will be at 137 Toiſes on a ſtraight Line; 140 on the Sides of a Dodecagon; 150 on thoſe of a Hexagon; and 160 on a Pentagon, or nearly ſo; that the ſtrongeſt ſimple and unravelined Fronts raiſed on a right Line will be about 147; on a Dodecagon 150; and about 160 on a Hexagon. Upon the ſame Principles, and from a right Conſideration of what is already ſaid, with regard to regular Fortification, it will be eaſy for an Engineer of moderate Capacity, to adapt in the beſt and moſt advantageous manner, any regular defenſive Conſtruction to a Circumference of any Diameter; and when more ſuperficial and leſs expenſive ones are required, he will know alſo how to form the Deſign, ſo as that it ſhall be the ſtrongeſt nearly that can be raiſed at the determinate Sum that may be allowed for the Execution of it.

CHAP. XV.

Of the Defences of the ninth Method.

152. ALL the ſimple defenſive Conſtructions that I have yet ſeen, are equally liable to one conſiderable Diſadvantage, which is, that the covered Way and Creſt of the Glacis, before the Faces of the Baſtions, are ſeen very obliquely in Flank from theſe Faces; and more or leſs ſo, according as the Angle of the Baſtion is more or leſs open. Hence one eſſential Reaſon why ſimple Fronts have a leſs degree of Strength, in proportion to their Expence, than ravelined ones (148, 150.); for the Length, Difficulty and Fatality of the Attack in ravelined or more complex Methods,

thods, depends chiefly, as we have already obſerved (139), on the powerful Reſiſtance that is oppoſed to the Progreſs of the Enemy's Sap along the Creſt of the Glacis, the covered Way, and the Faces and Ramparts of the Outworks. Now if a ſimple Method is deſigned ſo as to obviate the abovementioned Inconvenience, and occaſion the covered Way and Creſt of the Glacis to be flanked in the moſt direct manner by the Baſtions; and without incurring any other material Diſadvantage, or increaſing the Expence, it muſt needs be allowed that a very important Point is gained, and that ſuch a Conſtruction will have the aſcendant of every other ſimple Method that has hitherto appeared. The Conſtruction which is repreſented by Fig. 4. Pl. IX. will be found, I preſume, to anſwer theſe Intentions in every reſpect.

153. The Side of the Dodecagon upon which this Method is conſtructed, meaſures 150 Toiſes (148); the Perpendicular 30; and the Face of the Baſtion 48; the Creſt of the Breaſtwork of the Face L of the Baſtion, its Tenaille D, its Flank I, and that of the Curtain is 18 Feet above the Level of the Field; the low Face C, 12; and the low convex Flank 7. In this Method it may be obſerved, that the Extremity A, of the Face of the Baſtion is inflected ſo as to form a right Angle with the interior Line of the Creſt of the Glacis P, produced inwards; which I ſhall afterwards term the Flank of the Face; and that the interior Portion B, which is a Continuation of the Creſt of the Glacis produced, forms, by its Junction with the former A, a right angled ſingle Tenaille in the Face of the Baſtion: This laſt B, I ſhall, for Diſtinction's Sake, term the Flank of the Shoulder. It is alſo remarkable, that the inward Line of

the Counterſcarp of the great Ditch, is directed to the Flank of the Baſtion at 5 Toiſes from the Angle of the Shoulder.

154. The covered Way is, in conſequence of this Conſtruction, is flanked directly from the convex Portion of the Flank of the Baſtion, and the Glacis is more directly expoſed in Flank to the Fire of the Face of the Baſtion. The Enemy's Lodgement P S, on the Creſt of the Glacis, will be ſeen into and commanded in the ſtrongeſt and moſt direct manner from the Flank of the Face A: The breaching Battery of the Enemy on the Counterſcarp T, will be wholly, and pretty directly ſeen from the Flank of the Shoulder B; and their Counterbattery, which is dreſſed on the Glacis at G, againſt the Defences of the oppoſite Flank K of the Baſtion, will be wholly ſeen from the Flank of the Shoulder D; and wholly and directly by the great Flank K againſt which it is directed, and by the Flank of the Face V; which two laſt only, amount to above 30 Toiſes; and the Fire of the Flanks of the Shoulders B, D, will be of great Efficacy againſt the Enemy's Batteries on the Counterſcarp and Creſt of the Glacis, on account of their Proximity to theſe Batteries. The Flanks of the Faces do alſo mutually defend each other, and the Breaches of the Baſtions, and do reciprocally flank their reſpective Branches of the Glacis. The low Face C of the Baſtion, is depreſſed 6 Feet below the Tenaille D within it, to allow the Tenaille to fire over its Creſt; and the Field is well commanded by the high Face L, and the Flank of the Shoulder B. The inward Place of Arms N, is powerfully commanded by the convex Portions of the Flanks of the oppoſite Baſtions, by the oppoſite Flanks of their Faces, and by the Curtain, and at a

ſmaller Diſtance, and with more Efficacy than in the common ſimple Conſtructions; becauſe the Counterſcarp is directed to the Flank of the Baſtion at 5 Toiſes from the Angle of the Shoulder. The Traverſes are ſo ſituate as to form the Flanks of a Retrenchment or Redout, as that diſtinguiſhed by the pointed Lines in the Place of Arms N, which may be thrown up occaſionally; and which will be directly flanked from the Flanks of the Faces D, and capable of making an obſtinate Defence: Nor can it be of any Uſe to the Aggreſſors, becauſe it is ſo much ſubjected to the Command of the Place. This Method therefore, of conſtructing the Traverſes at the inward Places of Arms of the covered Way, will be preferable to any other. Temporary Traverſes alſo may be made occaſionally in the covered Way, as they are found neceſſary.

155. Perhaps it may be objected to this Conſtruction of the Baſtion, that the Enemy, by directing the Fire of their breaching Battery againſt the low Face C, will more eaſily open the Baſtion; on the contrary, it is manifeſt, that it will be more difficult to open the Baſtion in that particular Part, than in the high Face L; becauſe the Breaſtwork of the Tenaille D, will ſtill remain entire, after the low Face C is ſapped and demoliſhed by the Enemy's Cannon; and the Aggreſſors will, in that Caſe, be under a Neceſſity of attaching the Miner, in order to open the Baſtion: And even ſuppoſing it were eaſy to effect an open Breach by battering theſe low Faces, the Tenailles of the Baſtion would, by that Time, have had their Effect; which as we have already obſerved (154), conſiſts in oppoſing a moſt powerful Reſiſtance to the Approaches of the Aggreſſors, and to the Progreſs of their Saps on the Creſt of the Glacis and covered

Way, and to their Batteries on the Counterſcarp; and they afterwards defend their reſpective Breaches.

156. The Lengths which I aſſign to the exterior Side, the Perpendicular, and Face of the Baſtion in this Conſtruction, are productive, as I conceive, of the ſtrongeſt ſimple Fronts which a Circumference of 290 Toiſes Radius, is ſuſceptible of, or nearly ſo; provided that the great Length of the Flank, agreeable to the Opinion of ſome Engineers, overballances the Advantages which would ariſe in conſequence of a much ſhorter one (69); but that it actually does ſo, I muſt own, is not at preſent my Opinion (69, 70). If this Circumference of 290 Toiſes Radius, is required to be fortified at a leſs Expence, and according to this Method, the Fronts muſt be extended, and their Number and that of the Baſtions, conſequently diminiſhed; and the Perpendicular and Face of the Baſtion muſt be ſhorter, in proportion to the Length of the exterior Side, than they are in the Conſtruction before us; ſo as that the Expence of executing the Enceinte do quadrate with the Sum that may be alloted to that Purpoſe.

SECT.

SECTION III.

Of IRREGULAR FORTIFICATION.

CHAP. I.

The Method of computing the Strength of each of the ſeveral Fronts of any irregular Enceinte that is raiſed on a plain horizontal Field; exhibiting the Principles and Art of fortifying irregular Circumferences traced on the like uniform champian Plain.

157. IRregular Fortification is by far the moſt various and extenſive of any of the Branches of the Science of Engineering, and by much the leaſt underſtood; ſo little indeed, that among the many Authors that have written concerning Engineering, there is not one who has yet attempted to enter into the Spirit of irregular Fortification, or given any tolerable Idea of it: Neither has Marſhal Vauban, nor General Coehorn, left us any Thing in Detail on this Subject; notwithſtanding their conſummate Skill in the Practice thereof is ſufficiently manifeſted by the judicious Diſpoſition of the Works of ſome irregular Places which were fortified by theſe able Engineers. The Doctrine of this Branch of Engineering is alſo of the moſt general Uſe, there being very few Places that are not irregular, either as to the Figure of their Circumference, or in their Situation:

And as it teaches the Method of fortifying Places of irregular Circumferences and Situations, and by conſequence how to form an exact Judgement of the ſtrong and weak Fronts of ſuch Fortreſſes, and the Proportions they bear to one another in point of Strength, on which depends the forming of Attacks againſt them to the beſt Advantage; ſo the Study of it is not confined ſolely to the Engineers, but alſo extends to the Officers of the Army; and thoſe particularly who have apparent Proſpects of riſing to a high Rank, and of having, ſome Time or other, conſiderable Commands.

158. Notwithſtanding the Variety in the Forms and Diſpoſition of the Works of irregular Fortreſſes, ariſing from the Diverſity of the Figures of their Circumferences, and their particular Situations with regard to the Sea, Rivers, Marſhes, high, rocky, hilly, and uneven Ground, and numberleſs Circumſtances depending on theſe, may be regarded as infinite, yet there are certain Principles whereon irregular Fortification depends, in a very conſiderable degree, and which, when known, will give us juſt and diſtinct Notions of it, and render it eaſy to fortify the moſt irregular Polygons traced on horizontal Plains, to as great an Exactneſs as the particular Figures of their Circumferences will admit (176).

159. In order then to demonſtrate the Method of computing the Strength of each of the ſeveral Fronts of an irregular Enceinte conſtructed on a horizontal plain Field, firſt ſimple, then ravelined, and conſequently to exhibit the Principles on which the fortifying of irregular Places chiefly depends, we ſhall firſt adduce the Portion H, C, D, X, of an irregular Circumference, with its ſeveral Sides, fortified in

the moſt ſimple Manner, and conſiſting each of 160 Toiſes, except the Side G C, which is only 100; and ſhall ſuppoſe each of the Fronts thereof, that are included between G and E, regularly attacked.

160. Now it is evident, that the firſt and ſecond Paralels of the Attack of the Front A B, muſt extend further to right and left than thoſe of the Attack of the Front D E; and that the Extremities K, L, of the Paralel which ſuſtains the ricochet Batteries in the Attack of the Front A B, and theſe Batteries ſuſtained thereby will approach nearer to the Fire of the collateral Fronts G C, C A, B D, D E, than the Extremities (P) of the Paralel ſuſtaining the ricochet Batteries in the Attack of the Front D E to the Fire of the Fronts collateral thereto. The direct Batteries raiſed on the Paralels, to command and ſilence the Fire of the Front A B, will alſo be more expoſed to the Fire of the two collateral Fronts than thoſe of the Attack of the Front D E to its collateral Fronts.

161. It is alſo evident it will be much more difficult to approach the ſaliant Angles of the covered Way before the Baſtions A B, than thoſe before the Baſtions D E, becauſe the Trenches M M, puſhed on towards the former, are more liable to be enfiladed, which will oblige the Enemy to make them ſhorter, and turn them oftner, and at very acute Angles: The Execution of them will therefore be tedious, and difficult, and fatal to the Beſiegers.

162. The Beſiegers, after they have puſhed their Approaches to the Creſt of the Glacis of the Baſtion A, will yet have Difficulties by far the greateſt to ſurmount. The great Obliqueneſs of the Counterſcarp Z before it, with reſpect to the Flank F of the Baſtion B, will occaſion their

Counterbattery, againſt that Flank, to extend from Y to Z; nor will it, even then, contain a Number of Cannon ſufficient to command the ſaid Flank, on account of the oblique Direction of the Ambraſures; which will alſo weaken conſiderably that Battery. The breaching Battery of the Beſiegers, extending from o to o, will be almoſt wholly expoſed, in a pretty direct manner, to the Flank i of the Baſtion c, and to the oblique Fire of the Curtain w. Conſequently the ruining and commanding of the Defences of the oppoſing Fronts of the Place will be accompliſhed; and alſo a compleat Breach, with the utmoſt Difficulty and Danger. The Paſſages of the great Ditch will be moſtly ſeen in reverſe from the Flanks of the adjacent Baſtions; which will occaſion the Aggreſſors to make them with double Epaulments; they will therefore be tedious and dangerous in the Execution.

163. In the Attack of the Baſtion D, the Counterbattery at s, oppoſes the Flank g of the Baſtion E, in a direct manner; the breaching Battery extending from n to n, cannot be ſeen from the Flank d of the adjacent Baſtion B, nor the Paſſage of the great Ditch in reverſe; and the other Advantages attending the Baſtion A, are alſo in a conſiderable leſs Degree to the Baſtion D: The Front D E, will therefore be of a Degree of Strength conſiderably inferior to the former A B. The Front D E, again, compared to the Front G C, will have the Aſcendant: For, in the Attack of the latter, the Flanks of the Parallels (R), will not extend quite ſo far to Right and Left, before the collateral Fronts, as thoſe (P) of the Attack of the Front D E; and the Returns of the Trenches (m m), will run over a very little leſs Ground, and be more eaſily executed in the

Attack of the former G C, than in the Attack of D E; the direct Batteries againſt this Front G C, and alſo thoſe in ricochet, will be expoſed to a narrower oppoſing Front of the Place, than thoſe againſt the Front D E; and the ricochet Batteries (R) againſt the former (G C), will recede further from the collateral Fronts. But when the Beſiegers come upon the Counterſcarp of the Front G C, the Reſiſtance oppoſed to them by the Place, will be very conſiderable, by reaſon of the Narrowneſs of this Front, whoſe Flanks are as long, and as direct as thoſe of the other Fronts; beſides, that the Faces of its Demibaſtions defend the covered Way and Creſt of the Glacis, in a much directer manner than thoſe of D E; which Advantages will very nearly ballance the Diſadvantages which it incurs, with reſpect to the Particulars juſt mentioned, compared with the Front D E. But the Baſtions G C are ſmall, and their Angles too acute; which will give the Superiority in favour of the Front D E.

164. From what is ſaid then (160 to 163), I am of Opinion, that if a particular Eſtimate were made of the Times required in carrying on the ſeveral Works in the Attack of each of theſe Fronts A B, D E, G C, including the inveſting of the Fortreſs, the Amount of their reſpective Strengths would be nearly as follows; *viz.* The firſt A B 32 Days, that is, 16 Days each Baſtion; the ſecond D E 20 Days, or 10 each Baſtion; and the laſt G C 16, or 8 each Baſtion: Conſequently, the Strength of the Front B D, will be 26 Days; and that of the Front A C 24. Theſe, and the following Eſtimates are, as I conceive, moderate, and rather below, than above the real Strength of the Fronts;

notwithſtanding I ſuppoſe no Countermines to be practiſed by the Beſieged.

165. Now if we ſuppoſe the long Side C D inverted and extended, ſo as to form the concave Segment C V D, and ſimple Fronts, as thoſe included in a right Line, between C and D, conſtructed on three Sides, C a, a b, b D, of equal Lengths inſcribed therein; it is evident, that the Strength of the centre Baſtions a, b, will, when thus retired, and with opener Angles, be conſiderably increaſed, being more difficult to be approached; and that the Strength of the Baſtions C, D, will be proportionably diminiſhed, becauſe they will, on the contrary, become ſtill more acute; and the Attacks of them leſs commanded by the collateral Fronts on the Side of the flat re-entring Baſtions (a b); ſo that the Sum of the Strengths of the Baſtions C, a, b, D, which are ſuppoſed to be conſtructed at the Angles of the Sides inſcribed within this concave Segment, will ſtill be the ſame, or nearly ſo, as in their firſt ſtraight Poſition.

166. Again, if we ſuppoſe ſimple Fronts conſtructed on three equal Sides inſcribed between C and D, in the convex Segment G T E, it is evident, that the Strength of the intermediate Baſtions e, f, ſuppoſed to be conſtructed within this concave Segment, will, on the contrary, be diminiſhed; and that of the Baſtions C, D, proportionably increaſed; ſo that the Sum of their Strengths will ſtill be the ſame, or nearly ſo, as in their firſt ſtraight Poſition; and the Strength of each of the Baſtions e, f, will be very nearly equal to the Strength of the Baſtion D; any Difference that ſubſiſts, depending on the Exceſs of the Length of any one of the exterior Sides of the Fronts included between C and D in the convex Segment, above D E, which is trivial: Therefore,

fore, ſuppoſing the Sides equal, the Baſtions e, f, d, will be alſo each of the ſame degree of Strength, the Angles of the Circumference and their Conſtructions being ſimilar; which degree of Strength will conſequently amount to 13 Days each Baſtion; and that of the Baſtion c to 11 Days, amounting in all to 50 Days; equal to the Sum of the Strengths of the Baſtions c, a, b, d, conſtructed on a ſtraight Line.

167. If the right Line c d is produced ſo as to admit of another Baſtion in the Middle, that Middle or Centre Baſtion will be ſtronger than either of the Baſtions a, b, of this Figure, Pl. x. becauſe it will be more difficult to ſcour its Faces by the Ricochet; and the Flanks of the Attack, which is formed againſt it, will be ſtill expoſed to a greater Front of the Place, and more to the Sallies of the Beſieged: But the Strength of its two collateral Baſtions will be the ſame as of the Baſtions a, b, of this Figure; and that of the two extreme Baſtions alſo the ſame as of c, d: And if this long ſtraight Line c d, is ſuppoſed to be extended until it admits of four flat Baſtions; in that Caſe the Quantity of Strength of each of the two Centre Baſtions will be the ſame, and equal to the Centre one in the Caſe laſt ſuppoſed; and the two flat Baſtions collateral to theſe, will be alſo of equal Force with the collateral ones of the Centre Baſtion of the former Caſe, or to the Baſtions a b of this Figure, Pl. x.

168. What I have ſaid, is ſufficient, I imagine, to render conſpicuous the Method of computing the Strength of each of the ſeveral Fronts of any irregular ſimple Enceinte, conſtructed on a horizontal Plane, and the Proportions they bear to each other in point of Strength. But if Ravelins

are added to theſe ſimple Fronts, we ſhall find, that their reſpective Acquiſitions of Strength which reſult thence, will be very different. Therefore, in order to underſtand thoroughly this Branch of Fortification, as far as it regards fortifying irregular Polygons on a plain horizontal Field, we muſt ſtill conſider it in other Views.

169. To proceed then, in this Inquiry, into the Nature and Principles of irregular Fortification, let us take a View of the ſucceeding Figure, Plate XI, which is made up of the former ſimple Enceinte, with the Addition of a Ravelin to each Front. Now it is evident, that the Ravelin O of the Front A B will be of more difficult Acceſs to the Beſiegers, and have its Glacis, and the oppoſite Field, commanded with a much higher degree of Force by the collateral Ravelins F, S, than the Ravelin of the Front D E by the Ravelins collateral thereto: By means alſo of the Ravelins F, S, the Faces of the Demibaſtions of the Front A B, ſince they are directed to the Faces of theſe Ravelins, are covered, in ſome meaſure, from the Ricochet, whereby it will be rendered of more precarious Effect againſt theſe Demibaſtions, which doth not take place in the Fronts D E and G C, in conſequence of their collateral Ravelins. It is alſo evident, that the Beſiegers muſt puſh their Approaches to the ſaliant Angles of the covered Way of the Baſtions A, B, in the Intervals of the Ravelins F, O, S, with the utmoſt Difficulty and Danger; by reaſon theſe Ravelins are ſo cloſe, in conſequence of the Narrowneſs of their reſpective Fronts, and ſo ſaliant in reſpect of theſe flat Baſtions A B. The Counterbatteries of the Enemy againſt the Flanks of the Demibaſtions of the Front A B, muſt extend cloſe to the covered Way of theſe collateral Ravelins F, S; which Batteries muſt

therefore be greatly ſubjected to their Command: The retired Flanks of theſe collateral Ravelins will alſo bear againſt the breaching Batteries of the Aggreſſors, and in Reverſe againſt the greateſt Part of their Paſſages of the great Ditch: For theſe Reaſons it will be impracticable, if the Defence is good, to reduce one of the flat Baſtions A H, without being obliged to take two Ravelins; or both of them, without taking three Ravelins. But leſt this ſhould be diſputed, which, however, could not admit of any doubt if theſe Fronts were contracted to about 145 Toiſes, with Ravelins of the ſame Dimenſions as thoſe of the Figure before us, I ſhall only ſuppoſe that the Aggreſſors are obliged to make themſelves Maſters of the greateſt Part of the covered Way of the collateral Ravelins F, S, and raiſe high and ſtrong Epaulments to command their Faces on the Side of the Attack, and to cover their Batteries on the Counterſcarp; which, indeed, will not amount to a great deal leſs Labour, nor be much leſs fatal to the Enemy, than the intire Conqueſt of theſe Ravelins: Therefore we may reaſonably allow for the Ravelin O of the Front attacked (A B) a reſiſting Force equal to 8 Days, and 10 Days on account of the Defence derived to this Front from theſe collateral Ravelins: So that the Front A B will have an Acquiſition of Strength of 18 Days, in conſequence of the Ravelins. But if the Fronts of this long Side C D were extended to 200 Toiſes, their Strength, as we have ſaid before (41), would then be conſiderably diminiſhed, not only by the lengthening of the Line of Defence, and abating thereby the Efficacy of the Fire of the commanding Fronts that oppoſe the Counterſcarp, but alſo by making the Ravelins recede further from each other, and from the Batteries on the Glacis and covered Way; and by conſequence diminiſhing, in a conſiderable degree, their great Command of theſe Batteries, and of the Approaches and Lodgements of the Aggreſſors that are puſhed forward, and eſtabliſhed on the intermediate Glacis and covered Way. The Front D E, by means of its Ravelin, at 8 Days,[*] and a Defence of 4 Days which it derives from its collateral Ravelins, will acquire an additional Force of 12 Days; and the Front G C, by reaſon of the Smallneſs of its Ravelin, and the Acuteneſs of the flanked Angles (63) will, together with the Defence afforded by the collateral Ravelins to the Baſtions G C, amount to no more than 10 Days; the intermediate Front B D will conſequently have, by means of its Ravelin, and the collateral ones, a Reinforcement of 15 Days, and the Front A C 14; therefore the Strength of each of theſe Fronts, conſtructed with Ravelins, as in the Figure before us, will ſtand thus:

Fronts.	Their Strength ſimple as in Pl. x.	Acquired by the Addition of Ravelins.	Their full Strength ravelined as in Pl. XI.
A B	32	18	50
D E	20	12	32
G C	16	10	26
B D	26	15	41
A C	24	14	38

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[*] I am of Opinion, that the Ravelin of the Front A B, ought to have been eſtimated at 10 Days, becauſe it yields a greater Reinforcement to its proper Front than is given by the Ravelin of the Front D E to this laſt Front, in conſequence of its being more ſaliant with reſpect to the Baſtions; conſequently, the Front A B will have an Acquiſition of Strength of 20 Days, in conſequence of its Ravelins and the collateral ones. This Remark, however, muſt ſuffice, without altering the Figure and the whole Eſtimate for ſo ſmall a Matter.

170. It remains now to fortify theſe ſeveral Fronts, each to the ſame degree of Strength, and equal to that of the middle Front A B ravelined as in this Figure, Pl. XI. which will not be very difficult, now that we have found the Proportions they bear to each other in point of Strength; and which, I conceive, is effected in Pl. XII. with as much Exactneſs, nearly, as is conſiſtent with the particular Figure of this Portion of an irregular Polygon.

171. In this finiſhed and compleatly fortified Portion of an Enceinte, Pl. XII. it muſt be obſerved, that the additional Outworks of the Fronts collateral to the Front A B, increaſe alſo, in a good meaſure, the Strength of this laſt Front, by retiring it from the further Aggreſſors, and commanding more powerfully the Flanks of the Attack thereof; by which means it acquires, as I conceive, a Reinforcement of 5 Days more: It will alſo be neceſſary to give a Redout of 3 Days to the Ravelin of this Front A B: So its full Strength in this Figure, will amount to 58 Days.

172. In the Attack of the Front D E, the Beſiegers muſt take 4 Lunettes at 6½ Days each, amounting to 26 Days; which, added to 32 for the Baſtions and Ravelins, gives 58 *.

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* Perhaps it may be objected to this Eſtimate, (146) that ſome Abatement ought to be made of the degree of Strength aſcribed to the ravelined Fronts of the preceding Figure, Pl. XI. in conſequence of the Addition of great Lunettes in the covered Way in this Figure, Pl. XII. becauſe theſe Pieces intercept, in a great meaſure, the Fire of the Baſtions againſt the Field and Glacis, and the mutual Defence of the Ravelins. This Deficiency, however, is compenſated, in a great meaſure, by the great Command of the Lunettes, by means of the Baſtions and Ravelins; for the Lunettes are valued, in this Eſtimate, rather under their real Force.

173. In the Attack of the Front G C, the Beſiegers muſt take 2 Lunettes of 6½ Days each; 2 Counterguards of 7 Days each; a ſmall Ravelin and its Envelope at 13; and 2 low Flanks at 2 Days; in all 42; which added to 16 Days for the Baſtions, gives 58.

174. In the Attack of the Front B D, they muſt take 2 Lunettes at 13 Days, and 1 Day only I allow of borrowed Strength to the Baſtion B, in the Attack of this Front, which it derives from the Outworks of the extreme Front G C; and 3 Days for the Redout in the Ravelin; making in all 17; which, and 42 Days for the Baſtions and Ravelins, amount to 58.

175. In the Attack of the Front A C, they muſt take 1 Lunette of 6½ Days; 1 Counterguard at 7; the ſmall Ravelin of the Front G C with its Envelope at 13 Days; which, together with 1 Day of borrowed Force, added to 38 for the Baſtions and Ravelins, will amount to 65½.

Fronts.	Their Strength ravelined as in Pl. XI.	Acquired by means of additional Outworks.	Their full Strength compleatly fortified as exhibited in Pl. XII.
A B	50	8	58
D E	32	26	58
G C	26	32	58
B D	41	17	58
A C	38	27½	65½

176. So that the Strength of theſe ſeveral Fronts is adjuſted to an equal Ballance, except the Front A C, which is 7½ Days ſtronger than any one of the other Fronts, on account of the Narrowneſs of its left adjacent Front G C; which

occaſions the Works before it to be ſo ſmall and cloſe, and dependant on one another, that the Beſiegers cannot take one of theſe Baſtions G C, without being obliged to reduce both the Ravelin and Envelope of that Front: The Exceſs of Strength, however, of the intermediate Front A C, occaſions no additional Expence; nor can any, or but very little, be thereby abated: For if the Ravelin F is made ſmaller, or the Front A C longer, the collateral Fronts A B, G C, will be thereby weakened; and if we endeavour to accompliſh that juſt Equality that is aimed at by increaſing the Strength of the other Fronts, that of the Front G C muſt alſo be increaſed; and, conſequently, the collateral one A C; which will therefore ſtill overballance: The Perpendicular of A C may, indeed, be made a little ſhorter than that of the other Fronts; which, however, will occaſion but a very trivial Saving; and it will ſtill retain the Aſcendant: Neither can this Equality be obtained by giving vaulted Batteries to the Flanks of each of the other Fronts G C, A B, B D, D E; becauſe the Strength of the Front A B, will be thereby augmented in a greater degree, than that of any one of the Fronts G C, B D, D E (162). Therefore, we muſt reſt ſatisfied with having put their reſpective Strengths as nearly in Ballance as this Portion of an irregular Polygon will admit of.

177. If we ſuppoſe the Front A B to remain ſimple, as in the ſimple Enceinte, Pl. X. and the other Fronts to be fortified to the ſame degree of Strength, or as nearly ſo as the Figure of the Circumference will admit of; we ſhall find that the Strength of the Front A C will, in that Caſe, alſo exceed that of any of the other Fronts; and in a much greater degree than in the former Caſe. In order to

demonſtrate this, I give to the Fronts C A, B D, D E, each a Ravelin; to the Ravelin of the firſt of theſe C A, a Redout and low Flanks to its Demibaſtions; to the Ravelin alſo of the ſecond B D, a Redout; and to the laſt D E, 2 low Flanks, and 2 ſmall Lunettes in the re-entring Places of Arms: And then the Strength of each of theſe Fronts will be nearly equal to that of the Front A B, which, it muſt be obſerved, is now augmented to 42, in conſequence of a Reinforcement of 10 Days, which it acquires by the Acceſſion of the collateral Ravelins; the Front G C being, the while, ſuppoſed out of the Queſtion. But if this laſt G C is alſo required to be fortified to an equal Meaſure of Strength with the ſimple Front A B, which, and the other Fronts abovementioned, are now about 42 Days ſtrong each, it muſt be reinforced with one Ravelin at 7 Days, 2 Counterguards at 7 Days each, and 2 low Flanks at 2 Days; amounting to 23, which added to 16, the Strength of the Baſtions G, C, gives 39; nearly equal to the Strength of A B. Now the Aggreſſors, in their Attack of the Front A C muſt take, beſides the proper Ravelin thereof, alſo one Counterguard, and the Ravelin of the left adjacent Front G C (176), amounting to 14 Days; and juſt by ſo much, therefore, will the Front C A exceed the Strength of any of the other Fronts; ſo that the Difference, in this Caſe, in favour of the Front C A, is nearly double what it is in the ſtrong Enceinte.

178. But if we ſuppoſe the Front G C, Pl. XII. to be extended to 160 Toiſes; in that Caſe, the Baſtion C may be taken on the Side of the Front A C, without being under a Neceſſity of taking the Ravelin of the Front G C; and the Front A C may then be reduced to an Equality with the other Fronts.

179. Again, if we ſuppoſe D E to meaſure 200 Toiſes; in that Caſe, the left collateral Front B D will come to be inferior in Strength to any of the other Fronts in this Figure, Pl. XII. becauſe the Baſtion D may then be taken on the Side of the Front B D, without being obliged to take the adjacent Lunette K, of the collateral Front D E; unleſs the Lunettes thereof are conſtructed of an enormous Size, which would occaſion them to be too ſaliant, and more eaſily approached, and much leſs commanded by the Place (44): The Strength of the Front D E will, no doubt, be alſo diminiſhed, in conſequence of extending it to ſo great a Length; which, however, may be compenſated by an advanced Work before the ſaliant Angle of the Ravelin; which will affect little or nothing the Attacks of the collateral Fronts, on account of the great Length, in this Caſe, of the Front D E; whereas any Work that is added to the Front B D of 160 Toiſes, muſt alſo augment, in a good meaſure, the Strength of one or both of the collateral Fronts, unleſs the Deficiency can be made up by a Redout or Retrenchment in the Ravelin, without inward projecting Flanks, and by low Flanks to the Baſtions; whoſe Effect is almoſt wholly confined to the Front to which they belong.

180. Circumferences will often occur then, which, being irregular in the Lengths and Angles of their exterior Sides, will not be capable of admitting of fortified Enceintes, whoſe Fronts ſhall be preciſely equal among themſelves in point of Strength; and alſo frequently from particular Irregularities of the Situation. Where any particular Front, however, has the Aſcendant, as the Front A C, ariſing from the crouded Works of a collateral Front, which is narrow and ſaliant, from ſome unavoidable Cauſe; which Superiority

of Strength, therefore, it acquires without any additional Expence, but what muſt have been laid out on that narrow Front, with ſmall acute-angled Baſtions, to raiſe it to an equal Degree of Strength with the other Fronts: In that Caſe the Exceſs of the Strength of the Front A C can be no Fault, nor ſurely of any bad Conſequence. On the contrary, a weak Front muſt be highly pernicious, by rendering the Exceſs of Strength of each of the other Fronts of the Enceinte, above the abſolute Strength of this weak one, ſuperfluous and of no Effect: Such therefore muſt be carefully avoided, and muſt be fortified to the ſame degree of Strength with the other Fronts, as in the Caſe of the Front G C, Pl. XII. notwithſtanding the Strength of its collateral Fronts ſhould be thereby augmented.

181. If any Portion of an irregular Circumference, that meaſures we may ſuppoſe 432 Toiſes, is a Segment of a very great Circle, and forms an Angle, at each Extremity, with the collateral Portions of the Circumference, as the one which circumſcribes the Fronts of Bergenopzoome which were concerned in the Defence in the late Siege; if ſuch a Portion, I ſay, is required to be fortified with the ſtrongeſt Fronts it is ſuſceptible of, with Ravelins, and great Lunettes in the covered Way, it is evident, that it cannot be divided into three Fronts of 160 Toiſes each; which we have already ſhewn to be the moſt advantageous Length, nearly, in ſuch a Conſtruction, that any regular Circumference is ſuſceptible of (Chap. 1. Sect. 2.); and if we divide this Portion of 432 Toiſes into two Fronts, theſe will be a great deal too long; therefore, we muſt divide it equally in three Fronts of about 142 Toiſes each Front, if the oppoſite and collateral Ground is uniform; as Mr. Coehorn has

done, nearly, in the abovementioned Fronts of Bergenopzoome: Therefore, we are not to conclude from Mr. Coehorn's Conſtruction of theſe Fronts, that he was of Opinion, that a Front of about 140 Toiſes was the moſt advantageous, with Ravelins, and great Lunettes in the covered Way, for any regular Circumference; but that he judged theſe Fronts to be the ſtrongeſt which the Segment abovementioned of the Incloſure of Bergenopzoome was ſuſceptible of, in that particular Situation, with reſpect to its Extent, and Convexity, and the Angles which it forms with collateral Portions of the Circumference. From the ſame Cauſe we ſhall frequently be under a Neceſſity of extending or contracting the Fronts of particular Portions of ſimple or ravelined Enceintes, ſo as to adapt them in the beſt manner to the Segments which form theſe particular Portions, having therein alſo due regard to the Particulars juſt mentioned; being always careful, however, to make their Lengths approach as near as poſſible to thoſe of the ſtrongeſt Fronts of ſuch Conſtructions, when raiſed on regular Circumferences of the ſame Convexity with theſe Segments; which Lengths are determined by the Principles already exhibited (Chap. 14. Sect. 2.): But it will be better, however, to extend theſe Fronts to the moſt advantageous Lengths, by enlarging, in ſome degree, the Circumference, provided the Sum that is allowed for executing the Work will admit of it; and that the Engineer is not confined in his Deſign, by the Fronts of an old Enceinte, which he may be under a Neceſſity of making the beſt Uſe of that is poſſible, to ſave Expence. But if we examine, by the foregoing Principles, the Conſtruction of the Fronts beforementioned of Bergenopzoome, we ſhall yet find ſome Imperfection in them which we have overlooked in the ſixth Chaper of the preceding Section. For it appears from what is already ſaid (35 to 47, 156.), that Fronts conſtructed with Ravelins and great Lunettes in the covered Way, are ſtronger at 160 Toiſes each Front, on the Sides of any Polygon, or on a right Line, than when the Length of the Front is, in any conſiderable degree, greater or leſs than 160 Toiſes. Now the Front of Bergenopzoome, which is formed by the Baſtions Coehorn and Pucelle, and the intermediate Curtain, is weaker by Situation than either of the collateral ones; the Front on its Right, which is formed by the Baſtions Coehorn and Belvidere, having the Field on its Right covered by the Lines of Kykinpot, and the Ground before it moſt powerfully flanked and commanded by theſe Lines and their Redouts: And the Front upon its Left, which is formed by the Baſtions King William and Pucelle, has ſome ſtagnating Water at the Extremity of its Glacis, before the Angle of the Baſtion King William; and the Field before it is flanked and commanded, in a conſiderable meaſure, by the Lines of Halteren. Therefore, the weak Front of Coehorn and Pucelle ſhould have been made longer than it is at preſent, and the two collateral ones proportionably ſhorter, according to the Advantages of their Situation; becauſe the proper Strength of that weak Front would have been thereby augmented; and its borrowed Force, which it derives from theſe collateral Fronts, would be ſtill equivalent to what it is, in conſequence of the preſent Conſtruction of theſe Fronts. The proper Force of the weak middle Front of Coehorn and Pucelle would be greater, becauſe its Demibaſtions would then admit of a greater Length (47); and the Ravelin would alſo admit of being made larger and more defenſible, ſenſible, and, therefore, alſo ſuſceptible of a ſpacious and well flanked Redout; and the Lunettes would nevertheleſs admit of the ſame Capacity they have at preſent, and approach as near to the ſaliant Angles of the covered Way; the Lengths of the Lines, conſequently, of the direct and flanking Defences of the Place and Outworks, would be thereby little or nothing increaſed; nor would the Efficacy of the Fire of theſe Works therefore ſuffer any Diminution; and they would become more defenſible, and have a greater meaſure of reſiſting Force. The proper Force of each of the collateral Fronts would be abated in conſequence of their being ſo much contracted; and that of the Centre one proportionably increaſed, as we have already ſhewn: That Abatement, however, of the Strength of theſe collateral Fronts is compenſated by the Advantages ariſing from their particular Situations; and as they may have their Lunettes, which are adjacent to the intermediate Front of Coehorn and Pucelle, as capacious as they are in the preſent Conſtruction of theſe Fronts, they will yield as great a Reinforcement to that intermediate Front as they do at preſent; and the Beſiegers will therefore be under a Neceſſity, in their Attack of the Front of Coehorn and Pucelle, to reduce the collateral and adjacent Lunettes, before they can raiſe Epaulments a-croſs the great Ditch; or, indeed, if the Defence is good, before they can batter the Place in Breach with any Succeſs; becauſe Batteries may be raiſed in the Gorges of theſe collateral Lunettes againſt the breaching Batteries of the Aggreſſors, whoſe Effect will be very great on account of their Proximity to theſe Batteries, and the rather becauſe the Enemy can erect no Counterbattery againſt them. This Reaſoning, however, is in other reſpects ſo agreeable to the Principles on which Mr. Coehorn ſeems to have eſtabliſhed his Syſtem of Bergenopzoome, that we cannot doubt but he was conſcious of the Imperfection we have here diſcloſed: Therefore, I am of Opinion, that Mr. Coehorn has been compelled through Neceſſity to comply, in ſome meaſure, with the Lengths which theſe Fronts of Bergenopzoome had in the old Enceinte, in order to ſave Expence, and that he might not exceed the Sum to which he was limited; and he has the more readily given way to this, becauſe he has been, I ſuppoſe, of Opinion, that the Front which is formed by the Baſtions Coehorn and Pucelle is ſtill, notwithſtanding the Diſadvantages attending it, as ſtrong as the weakeſt Part of the Lines of Halteren, and the weakeſt Front of the Place within theſe Lines together, provided the Lines are not very well manned; and becauſe it will, in all Probability, ſeldom happen that they ſhall be well manned, notwithſtanding they were ſo in the late Siege; becauſe an Enemy of ſuperior Forces has it always in his Power to draw of the principal Strength of the defenſive Army, by penetrating the Country of his Opponents in another Quarter, and laying Siege to ſome other Town of equal Importance, or threatning ſo to do. What is ſaid in this and the preceding Chapters is ſufficient, I imagine, to give a clear, extenſive, and juſt Idea of the Theory and Conſtruction of defenſive Fronts, that are raiſed on a horizontal Plain: We ſhall next conſider them as they are variouſly affected by irregular Situations.

CHAP. II.

Of irregular Situations in general.

182. IN the preceding Chapter, I have clearly, I preſume, demonſtrated the Method of computing the Strengths of the ſeveral Fronts of any irregular Enceinte that is conſtructed on a plain champian Field, and the Method of fortifying any irregular Polygon traced on the like horizontal Plain, ſo as that the ſeveral Fronts of the Circumference ſhall be preciſely on an equal foot, in point of Strength, or as nearly ſo as is conſiſtent with the particular Figure of the Circumference; in which conſiſts, almoſt wholly, the Principles and Art of fortifying irregular Places. For it will be eaſy for any Engineer of a moderate Capacity, who is well verſed in theſe Principles, to adapt defenſive Enceintes to any Situation, or invironing Ground whatſoever; for, in all irregular Situations, the artificial Strength of each Front muſt be determined, with reſpect to the Figure of the Circumference, by the Principles already laid down, after making proper Allowances for the natural Strength or Weakneſs of each of them, depending on the Quality of the ſubjacent and circumjacent Ground; which is always obvious and eaſily diſcerned, eſpecially where ſuch natural Strength or Weakneſs exiſts in any conſiderable degree: And the ſtronger the Situation of any Fortreſs or Fort naturally is, it not only requires by ſo much the leſs artificial Strength, but is alſo more eaſily deſigned, and with leſs Skill; and in high craggy Situations there will be often a Neceſſity of tracing the Circumference according to the Humour, or irregular

Contour of the Steeps and Precipices of the Rock, or rocky Ground on which the Enceinte is to be raiſed. And every one of common Senſe, who has ever beſtowed a Thought on Engineering, muſt needs know, that high, ſtrong, commanding, and enfilading Grounds are to be guarded againſt, by means of Cavaliers, high Traverſes, raiſing the Breaſtworks on the Side of the ſtrong Eminences, by the Interpoſition of proper Outworks, or by poſſeſſing them by means of advanced Works: And that the Declivities of Grounds deſcending towards the Field are to be ſeen; and the Bottoms of hollow Grounds ſeen into, by means of advanced Works, when there are ſuch Declivities, and hollow Bottoms at a ſmall Diſtance from the Place; which would otherways give the Enemy an Opportunity of breaking Ground very near the Place: And that Fronts that have the Field before them marſhy, ought to be made longer, and weaker than the other approachable Fronts, in proportion to the Advantages ariſing from the Moraſs, tho' not ſo much as to weaken, in any conſiderable degree, the collateral approachable Fronts: And that the Situations that are moſt commanding, and leaſt commanded, or that are inacceſſible or difficult of Acceſs, by means of rocky, or high ſteep Ground, invironing Water, or Moraſs, or otherways, are the beſt with reſpect to Strength: And that thoſe Situations are to be prefered for the Conſtruction of Fortreſſes, or Forts, where natural Strength can be obtained in the greateſt degree, together with all the Views and Purpoſes for which theſe ſtrong defenſible Places are principally intended; due Regard being alſo had to the Commodity and Good of the Inhabitants, or Gariſons, with regard to Trade, Proviſions, freſh Water, Wholeſomeneſs of the Air, &c.

183. It may not be unneceſſary to obſerve, that in Fortreſſes ſtanding on the Border of the Sea, or of great Lakes, where the long Side next the Water cannot be battered from any oppoſite Shore, the Faces of the Demibaſtions whoſe Angles terminate in the Water, at the Extremities of the long Side, and the Faces of the Works before them which regard the Field, cannot be ſcoured by the Ricochet; nor can the Flanks of the ſaid Demibaſtions be plunged into in reverſe by the Ricochet; which will compenſate, in ſome meaſure, the Diſadvantages ariſing to theſe Works, from their Situation, that are ſpecified in the Sequel (194). It is alſo certain, that Fortreſſes thus ſituated will have the two Baſtions, or Demibaſtions, at the Extremities of the long Side that is waſhed by the Sea, ſtronger than any two of the landward Baſtions of the Enceinte, provided the Situation is plain and regular, and the Conſtruction of the ſeveral Land Fronts ſimilar, and that of the Extremities of the long Side judicious; and that the Tide riſes to a good Height againſt the Batterdeaux at the Extremities of the great Ditch; becauſe the Enemy cannot, in that Caſe, without much Difficulty, raiſe Batteries againſt the Flanks of the adjacent Baſtions, which command the great Ditch of the Faces of the Demibaſtions which terminate in the Sea (189).

184. In low flat Countries, where Fortreſſes have generally ſome Portions of the invironing Field moraſſy, it will ſometimes happen that a Front of the Enceinte ſhall have the Field before it dry, and a large Moraſs to its Right and Left, running from the Extremity of the Glacis or Fore Ditch, a conſiderable Way out into the Field. If the Situation of theſe Marſhes are ſuch, and the intermediate dry

Ground ſo broad, and of ſuch a Figure nearly as that the Faces of the Demibaſtions which form the Front within it (which Front I ſuppoſe meaſures 180 Toiſes) ſhall, when produced into the Field, juſt fall within the Verge of theſe collateral Marſhes, at a ſmall Diſtance from the Extremity of the Glacis; in that Caſe, the Front of 180 Toiſes will be as ſtrong as if it were contracted to 160 (the collateral Fronts being ſtill of the ſame Length in both Caſes), notwithſtanding the Advantages peculiar to this latter (35 to 48); becauſe, in the one of 180, the Faces of the Demibaſtions, and the covered Way before them, cannot be ſcoured by the Ricochet without conſiderable Labour and Danger to the Beſiegers; whereas the Faces of the Demibaſtions of the Front of 160 Toiſes, and their covered Way will be liable to that Diſadvantage, by reaſon the Lines of their produced Faces will run on the dry Ground, at a ſufficient Diſtance into the Field, ſo as to allow of erecting Batteries in Ricochet againſt them, before they invade the borders of the collateral Marſhes.

185. Theſe, (183, 184) and many other ſuch remarkable Circumſtances and Incidents will frequently occur in the Practice of fortifying irregular Places; but ſuch only as may be diſcerned, and have Works properly adapted to them by Engineers who have a common Share of good Senſe and Invention, and underſtand the Principles and Method which are already ſet forth; on which is founded the Art of fortifying irregular Circumferences traced on horizontal uniform Plains; more eſpecially if they have had ſome Experience in the Defence. Nevertheleſs, that this Branch of Engineering ſo complex, and hitherto ſo little known to unexperienced Engineers, may be developed, as

much as poſſible, from Obſcurity, and be more thoroughly underſtood, and eaſily acquired by Beginners, I ſhall give ſome Models of irregular Fortification, which are adapted to certain Situations that moſt frequently occur in Practice, and are moſt difficult to be fortified; with minute Details of the Ends propoſed by the particular Forms and Diſpoſition of the Works of each of them.

CHAP. III.

A circumſtantial Detail of the Situation and Conſtruction of the Enceinte of Hunningen on the Rhine; ſetting to View the natural Strength of certain Portions of it, and the Weakneſs of others, and the Allowances made by the Conſtructer in the Application of the artificial Strength, for putting the whole Enceinte in juſt Ballance; and the judicious Manner in which that Adjuſtment is effected. Being a perfect Model for the Conſtruction of Fortreſſes ſituated by the Sides of large Rivers, where the long Side next the River may be contained in one common Front of Fortification.

186. IRregular Fortification being of almoſt infinite Variety, and the Knowledge of it depending, in a great meaſure, on Experience in the Practice of Engineering; therefore a good Way to acquire juſt Notions of particular Parts thereof, will be to obſerve in what Manner the moſt ſkilful and experienced Engineers have ranged the Works of irregular Enceintes, and how they have adapted them to the various Circumſtances and Situations of the Ground, and with what Views; but as the Works of the

beſt Engineers are generally blended with the Works of old Enceintes, which they were under a Neceſſity of making the beſt Uſe of, to ſave Expence, and were not left to the free Scope of their Geniuſes, compleat and juſt Examples of this Kind are very ſcarce. Mr. Vauban has luckily left us Hunningen on the Rhine; a Work the moſt maſterly of the Kind, and a juſt Monument of the high Capacity of this excellent Engineer; I have therefore made Choice of this Fortreſs, as the moſt juſt Model of fortifying by the Sides of large Rivers, where the long Side next the River may be contained in one Front, not exceeding 230 Toiſes; and ſhall endeavour to unravel, and exhibit the Deſign of the Author, in the Conſtruction of the whole and the ſeveral Pieces of it, which will give the moſt exact Idea of the natural and artificial Strength thereof, and of the Method of conſtructing Enceintes in the like Situation. I have, to this End, inſerted a correct Copy, Pl. XIII. of the Plan which is given of that Fortreſs in a Book entitled, "Le Parfait Ingenieur François."

187. To proceed then to the unraveling of the Deſign and Uſes of the ſeveral Works of Hunningen, we ſhall firſt inveſtigate the Motives that have induced Mr. Vauban to give a much greater Length to the Front upon the Margin of the River, than to any other Front of the Enceinte, by ſetting to View the Advantages and Diſadvantages which reſult thence, their Nature and Effects; which will give a clear Idea of the Amount of the Balance, in favour of Mr. Vauban's Conſtruction. In order to this, it will be proper firſt to obſerve, that the Polygon which is formed by the exterior Sides of the Fronts of the Enceinte of Hunningen, is an irregular Pentagon, conſiſting of one long Side to the

River, and four Sides, each of them ſhorter than the former, and equal among themſelves, towards the Land. As the French Engineer has given no Scale to the Plan, we ſhall ſuppoſe that the great Ditch meaſures 16 Toiſes at the flanked Angle of the Baſtion; conſequently the long Side will meaſure 204, according to the Proportion its Length bears to the Breadth of the great Ditch, and each of the ſhort Sides 168.

188. Now it is evident, that the Angles which the Extremities of the long Side form with the collateral Sides will be ſmaller than thoſe of a regular Pentagon; and alſo neceſſarily the Angles of the two Baſtions, conſtructed within thoſe exterior Angles at the Extremities of the long Side, with reſpect to the Angles of the Baſtions of a regular Pentagon. The Diſadvantages, therefore, peculiar to narrow-angled Baſtions (63), muſt be induced, and will attend theſe Baſtions in a Meaſure adequate to the Exceſs of the Length of the long Side above the Length of any one of the other ſhorter and equal Sides of the Pentagon; and contribute, with other Diſadvantages that are ſpecified in the Sequel (194) to abate conſiderably of the Strength of theſe River Baſtions. The extending of the Side next the River to ſo great a Length is, nevertheleſs, productive of Advantages which will overballance a great deal the Diſadvantages that are thereby incurred; which I preſume will appear in the Courſe of this Reſearch.

189. In all Fortreſſes ſituated cloſe to the Sides of large Rivers, the Paſſage of the Ditch of the Demibaſtions that terminate in the River, at the Extremities of the Side that is waſhed thereby, may be rendered extremely difficult to the Enemy, becauſe the Ground for raiſing Counterbat-

teries on, againſt the Flanks which command the Faces and great Ditch of theſe Demibaſtions, will be ſo narrow, if the Conſtruction is judicious, and ſo much commanded, as in this Model, Pl. XIII. and the one following, Pl. XIV. as to render the erecting of Batteries thereon impracticable; and the Demibaſtions contiguous to theſe, (in the Conſtruction of Hunningen) that regard the River and belong to the River Front, are in very little Danger of being attacked; their natural Strength by Situation making up the Deficiency of artificial Strength. Conſequently, the two Baſtions at the Extremities of the long River Front of Hunningen, will ſtill, notwithſtanding of other Inconveniencies attending them (188, 194), be the ſtrongeſt in the Circumference, eſpecially if the covering Works on the oppoſite Bank are of ſufficient Strength and Extent.

190. What is chiefly required then in ſuch a Situation (189), is a Conſtruction that will, in the moſt ſimple manner, put the Landward Baſtions nearer on a Foot with the River ones in point of Strength; and this Mr. Vauban has very ingeniouſly effected, in his Deſign of Hunningen, by extending to a certain Length the Side next the River, above the Extent of any of the land Fronts: For, if we ſuppoſe the Extremities of the outward Side of the river Front to be terminated by the Periphery of the Circle which circumſcribes the other equal Sides, as I am inclined to believe they actually are upon the Ground, notwithſtanding they project a little without it in the Plan; if ſo, I ſay, it is evident, that the three Angles formed by the four ſhort and equal Sides will be each of them larger than the Angle of a regular Pentagon; and conſequently, the flanked Angles of the Baſtions conſtructed within them will be more open; there-

fore

ſore the mutual Defence of the Fronts conſtructed on theſe four ſhort Sides will be greater; and their reſpective proper Forces alſo more powerful and efficacious, in as much as theſe Fronts are ſhorter, and approach nearer to 160 Toiſes (142) than thoſe of a regular Pentagon inſcribed in the ſame Circle; ſince a Front of the latter will amount to 175 Toiſes nearly. The Ballance then, in favour of the four ſhort and approachable Fronts of Hunningen, in conſequence of Mr. Vauban's Conſtruction, with one long Side to the River, compared in point of Strength to the four Fronts of a regular Pentagon inſcribed in the ſame Circle, will be conſiderable, after compenſating the Diſadvantages; and this has been, no Doubt, one of Mr. Vauban's Motives for extending to ſo great a Length the Side next the River. But if the Extremities of the long Side doth actually project without the Periphery of the Circle which circumſcribes the other equal Sides, that will indeed occaſion the Angles at the Extremities of the long Side to be ſtill more acute; but then the two collateral exterior Angles will become proportionably opener; and conſequently the flanked Angles of the Baſtions conſtructed within them, and which by Situation are the weakeſt of the Enceinte (199); ſo that the Advantages thence ariſing will ſtill be nearly the ſame as in the former Caſe.

191. The following Advantages, which Mr. Vauban has alſo unqueſtionably had in View, ariſe purely from the particular Length of the river Front, in reſpect of the Length of the other Fronts of the Enceinte, and of the Extent of the oppoſite covering Works; whereof it will be equally productive, whether it projects or not beyond the Periphery of the Circle which circumſcribes the other four equal Sides.

Firſt, The Front contiguous to the River oppoſes, in conſequence of its greater Length, a larger Front to, and commands more powerfully the Works on the oppoſite Bank of the River, and the Hornwork in the Rhine; and Mr. Vauban has very judiciouſly extended it till the Faces of its Demibaſtions flank the covered Way of the Counterguards of the oppoſite Hornwork; and ſo as to bring the approachable Faces of the River Baſtions under the Cover of the Creſt of the Glacis of theſe Counterguards, from Batteries in Ricochet erected in the Field, on the other Side the River; and ſo as to occaſion alſo the Curtains of the collateral Fronts to be directed in right Lines M, N, that will fall obliquely on the Breaſtworks of the Wings of the Hornwork of the oppoſite Shore; by which means there is no Room left for erecting Batteries to ſcour them from thence by the Ricochet. Secondly, The great Length of the river Front occaſions the two contiguous and collateral Fronts to be expoſed more obliquely to the Fire of the Aggreſſors from the other Side of the River. Thirdly, The Inhabitants have a more extenſive Communication with the River, by means of the great Length of the river Front; and a more immediate and commodious one, with regard to Trade, in conſequence of its approaching nearer to the Centre of the Town. Fourthly and laſtly, Some ſmall Saving is gained in conſequence of extending the river Front to a greater Length than any of the other Fronts of the Enceinte, becauſe the Extent of the Circumference of the irregular Polygon of Hunningen, the five Sides of it being ſuppoſed to be inſcribed in a Circle, will be inferior by about 4 Toiſes to that of a regular Pentagon inſcribed in the ſame Circle: But as the Number of Baſtions and Ravelins will be the ſame in each, this Advantage is very inconſiderable; and it ſuffers yet ſome Abatement in conſequence of the Area of this irregular Pentagon, being a very little leſs than that of a regular one inſcribed in the ſame Circle.

192. From the whole then (187 to 191), I think it is clear, that the Advantages are conſiderable that are obtained by means of extending the Side next the River to a determinate Length above that of any of the other Sides, and with reſpect to the Extent of the covering Works of the oppoſite Shore, according to the Proportions Mr. Vauban has obſerved in the Conſtruction of the Works of Hunningen.

193. I ſhall now conſider wherein conſiſt the Strength and judicious Diſpoſition of the Body of the Fortreſs, and the ſeveral Pieces; and firſt of the Place and Ravelins, the Hornworks, the Demilune before the Baſtion D, and the Cavaliers of the Baſtions D, E, being, in the mean while, ſuppoſed to be taken away, that the Demonſtration may be more perſpicuous.

194. We have already ſhewn (189) that the Flanks which command the great Ditch before the acceſſable Faces of the River Baſtions cannot be ruined, or ſilenced by any Counterbattery of Cannon of the Enemy. This great Advantage, provided the covering Works on the oppoſite Side of the River, are of ſufficient Strength, and due Extent, will ſtill overballance the following Inconveniencies that ariſe from the Situation of theſe Baſtions, and in conſequence of the long Side; which will evidently appear in the Sequel. Firſt, The long Side that is waſhed by the River will not admit of ſo ſaliant a Ravelin, nor of ſo ſaliant Places of Arms as the land Fronts; which therefore will afford very little Defence to the collateral land Fronts that

terminate at the River: This Diſadvantage is alſo increaſed by lengthning ſo much the river Front, and thereby rendering the Angles of the river Baſtions, and the ſaliant Angles of their Counterſcarps leſs open; and cauſing the Ravelin to recede further from the ſaliant Angles of the covered Way before theſe Baſtions. Secondly, The river Baſtions, and the adjacent Ravelins (L, S,) of the Fronts that terminate at the River, are more eaſily approached than any of the other Baſtions or Ravelins that are more remote from the River; becauſe the Trenches of approach to the river Baſtion, and the adjacent landward Ravelin, that are directed to the Bank of the River, may advance by longer Stretches and at larger Angles, and have their Flanks, or Extremities on that Side, ſtill ſecured and ſuſtained by the River; a falſe or real Attack being alſo ſuppoſed to be carried on againſt the covering Works on the other Side; and theſe Approaches will alſo be expoſed to a narrower oppoſing Front. In the Caſe before us, however, theſe Approaches will be pretty much reſtrained by the ſhooting out of the Extremities of the covered Way (T) of the long Side; nor can the Enemy run, in this of Hunningen, a direct Trench along the Verge of the river Bank, by reaſon it is well flanked by the Faces of the river Baſtions, and by the Redout O on the higher Side of the Town; and ſeen in reverſe by the Redout R below the Town: This Redout (R) will alſo occaſion the Trenches of Approach that are puſhed on to the lower river Baſtion, to advance by cloſer and more frequent Turnings. Thirdly, The Beſiegers in the Attack of the river Baſtion, or of the Front that terminates at the River, will have an Opportunity of bleeding more eaſily the Fore Ditch, and the great one to a Level with the Surface of the River.

195. The firſt of theſe Diſadvantages (194) has no conſiderable bad Effect in the Model before us; the ſecond is of a little more weight; and as to the third, the Ditches may, with a very little more Trouble, be alſo bled from the adjacent Front on the Side of the Field. Therefore I think it is manifeſt, that the great Advantage abovementioned (189), peculiar to the river Baſtions, in judicious Conſtructions, will overballance all theſe Diſadvantages, and will give them ſtill the Superiority over the other Baſtions in point of Strength: And if the Flanks which command their landward, or approachable Faces, and the great Ditch before them, were conſtructed with vaulted Batteries, they would be thereby rendered almoſt impregnable.

196. The Baſtion which is the next ſtrongeſt in the Enceinte of Hunningen to theſe river ones, will be the Baſtion D, which is the remoteſt from the River: Firſt, Becauſe the Attack of the Enemy againſt this Baſtion will be expoſed to a larger Front of collateral Works, than that of any other Baſtion in the Circumference. Secondly, The Flanks of its Attack will not be ſuſtained by the River, unleſs they are continued on either Side quite to the Banks thereof; and the Attack will then be of great Extent, and expoſed to the whole Fire of the land Fronts of the Fortreſs.

197. The Baſtions C, E, are liable to the Diſadvantages that are peculiar to the Baſtion D, beſides theſe following: One Flank of the Attack of the Enemy againſt either of theſe Baſtions C, E, will be ſecured on the Side of the River againſt Sorties. The Enemy will have an Opportunity

of bleeding more eaſily the wet Ditches, eſpecially if they attack either of theſe Baſtions in the Face towards the River, and take the adjacent Ravelin on that Side; for they muſt take one Ravelin before they can make themſelves Maſters of a Baſtion.

198. The degree of Strength of each of the four Ravelins ſeems to me to be nearly the ſame; for altho' the Ravelins of the Fronts which terminate at the River are more eaſily approached than either of the other two on the land Side, yet their Faces which regard the Land cannot be ſcoured by the Ricochet; which will make up, in a great meaſure, that other Diſadvantage; and the Approaches to their Faces, which regard the River, will be very much difficulted, by their being expoſed to the Fire of the interior Breaſtworks of the projecting Extremities of the covered Way of the long Side. Therefore, I am of Opinion, that they are full as ſtrong, in this Conſtruction, as the two Ravelins which are moſt remote from the River.

199. From the whole then (194 to 198) it appears, that the river Baſtions A, B, are the ſtrongeſt; next to theſe the Baſtion D; and that the Baſtions C, E, are the weakeſt of the Enceinte of Hunningen. Therefore Mr. Vauban judged well in increaſing, as much as poſſible, the Strength of the three Baſtions towards the Land, (by ſhortening the landward Fronts, and enlarging their Angles, in conſequence of extending to ſo great a Length the Side next the River) above the Degree of Strength they muſt have had, were they conſtructed in the Angles of a regular Pentagon inſcribed in the ſame Circle.

200. The Exceſs of the Strength then of the river Baſtion A or B, above the Strength of the Baſtion D will, I conceive,

ceive, amount to 3 Days, and to 4 Days above that of the Baſtion E or C, at leaſt. Now if it ſhould be required to add ſuch Works as may ſuffice to put the ſeveral Baſtions and approachable Fronts of the Enceinte on an equal Ballance, in point of Strength, the invironing Field being ſuppoſed uniform, and equally advantageous with reſpect to the different Fronts, it may be effected by advancing a Lunette with a covered Way and Glacis, 5 Days 12 Hours ſtrong, before the ſaliant Angle of the Glacis of the covered Way of each of the Baſtions C and E; one Lunette of 4 Days before the Baſtion D; and one of 2 Days before each of the river Baſtions. The two firſt before the Baſtions C and E, yield to the collateral Baſtions next the River, a Reinforcement of 1 Day each, and to the intermediate Baſtion D, a Reinforcement of 2 Days; and theſe Lunettes before C and E derive, in their Turn, a Reinforcement of 16 Hours each, from the Lunette before D; and an Acquiſition of 10 Hours each, from thoſe before the river Baſtions: So that the Increment of Force which the Baſtions acquire by the Acceſſion of advanced Lunettes, will be to the Baſtions C and E, each 6 Days 14 Hours; to the Baſtion D 6 Days; and to the river Baſtions each 3 Days; which 3 Days deducted from the additional Force of each of the other 3 Baſtions C, D, and E, the Remainder will be, to a Trifle, equal to the Difference that ſubſiſted between theſe and the river Baſtions, in point of Strength, before the Lunettes were added; conſequently they will now be adjuſted to that Equality, nearly, in the Strength of the ſeveral Fronts and Baſtions, which was wanted; proper defenſive Pieces being, at the ſame Time, provided for guard-

ing

ing the Dams and Sluces at the Extremities of the Fore Ditch.

201. From what is ſaid then, it will be eaſy, I think, to diſcover the Intention of the Hornworks before the Baſtions C and E, and of the Demilune before the Baſtion D. In order to this, it may obſerved, that the Beſiegers cannot carry on an Attack againſt any ſingle Baſtion of the Enceinte without taking one Hornwork; if they attack one of the river Baſtions, they muſt take the Hornwork which covers the collateral Baſtion; and if they attack the Baſtion D, their Approaches will be enfiladed, and ſeen in reverſe from both Hornworks, and cannot be ſuſtained and ſecured againſt the Effect of Sallies, from theſe collateral Hornworks, their Ravelins and covered Ways; unleſs the Beſiegers take one Hornwork, and determine their Attack to that Side. Therefore it is to be preſumed they would rather chooſe at once to attack one of the Baſtions covered by the Hornworks, or rather to carry on two Attacks. If they carry on then two Attacks, ſuppoſe againſt the Baſtions B and E, they muſt take the Hornwork F, and the ſmall Redout O, at the Mouth of the Fore Ditch: And if they attack the Baſtions B and D, they muſt take that Hornwork, and the Demilune G; but the Strength of this Demilune (G), which is admirably well contrived to make a good Defence, and to render it difficult to raiſe Counterbatteries againſt the oppoſite Flanks, is conſiderably greater than the Exceſs of the Strength of the river Baſtion B, above the Strength of the Baſtion D, as appears from what has been already ſaid (200): And which Mr. Vauban has compenſated by the Addition of the Redout O, before the Baſtion B, which alſo ſerves to guard the Sluce of the Fore Ditch; and

by the Defence afforded, by the interior Breaſtwork of the projecting Extremity T of the covered Way of the long Side, to the oppoſite Glacis and covered Way: So that the ſeveral approachable Fronts of the Enceinte of Hunningen thus fortified, will bear the ſame Proportion to one another, in point of Strength, nearly, as in the Caſe above-ſuppoſed (200); the invironing Ground being ſtill ſuppoſed to be horizontal and homogeneous.

202. Now it may be asked, Why has Mr. Vauban placed before the Baſtions C and E, capacious Hornworks with Ravelins, when he might have put the ſeveral Fronts on an equal Foot, at a much leſs Expence, in the Manner above ſpecified (200)? The Anſwer to this is very plain, becauſe Mr. Vauban was of Opinion, that the Importance of the Place demanded a Fortreſs of a much greater degree of Strength; and it is worth while obſerving, that this judicious Engineer has beſtowed on it the Increment of Strength that was required, in the beſt and moſt frugal Manner poſſible; and which, I am inclined to think, could not have been effected at the ſame Expence, and with equal Simplicity, by any other defenſive Conſtruction. If two Hornworks, added to a Fortreſs of Importance, are ſo diſpoſed as that the Aggreſſors muſt take one of them, whatever Front or Baſtion of the Enceinte they attack, the Money beſtowed on them will ſurely be reckoned well and frugally laid out. It is alſo remarkable, that Mr. Vauban has, in this Conſtruction, judiciouſly placed the Gorges of the Hornworks at the outward Verge of the Fore Ditch, and has not terminated them on the Counterſcarp of the great Ditch; by which means they are well commanded, and flanked by the oppoſite and collateral interior Works, and command ex-

ceedingly well the Field; and ſo are not liable to the Diſadvantages attending thoſe whoſe Gorges are terminated on the Counterſcarp of the great Ditch, which are mentioned in the foregoing (125). Neither can the Aggreſſors cut off their Communication with the interior Works by the double Sap, becauſe their Gorges are of great Extent, and are terminated on the Counterſcarp of the Fore Ditch.

203. But the natural Strength of the Front A, C, is greater than that of any of the Fronts included between C and B on the land Side, on account of the ſmall River P; which incumbers, in ſome degree, the Attack of the Enemy on that Side, and will render ſomewhat leſs commodious the tranſporting of Artillery to the Batteries of the Attack, eſpecially if the Banks of the River are low and marſhy; and the Guards of the Trenches will be leſs readily ſuſtained againſt grand Sallies, notwithſtanding of the Bridges that may be thrown over it, which are alſo liable to be carried away in high and ſudden Floods of the River after heavy Rains; but chiefly becauſe the Field before the Front A C, eſpecially before the Baſtion A, and the Ravelin to its Left, and the Glacis of that Baſtion and Ravelin are commanded, and ſeen in reverſe from the Redout R, which is almoſt inacceſſible to the Enemy, on account of a Breadth of about 20 Toiſes of the Rhine, which runs between the ſmall Iſland whereon it is raiſed, and the hither Bank of the River. Therefore Mr. Vauban has compenſated the Want of that great Advantage to the other three Fronts, by giving Cavaliers to the Baſtions D and E, by which means the whole Enceinte of Hunningen is compleatly and equally fortified. It may alſo be obſerved, that the Form and Situation of the Cavalier is the beſt that can be imagined, be-

cauſe it defends and commands to the greateſt Advantage, the Ravelin, and its covered Way, and Glacis in Flank; and the oppoſite Counterſcarp, before the Angle of the adjacent Baſtion in Front: It has alſo a great Command of the Field; and effectually covers the Faces and Flanks from the Ricochet in reverſe. The Objection that is made to this Poſition of the Cavalier, that it leaves no Room for retrenching the Baſtion, is wholly trivial (49 to 55).

204. The Fore Ditch has undoubtedly a Batterdeau, or Dam of Maſonry at each Extremity, where it communicates with the Rhine; tho' the French Engineer has omitted them in his Plan: And there is alſo, no doubt, a Batterdeau at the Extremity of the great Ditch where it joins the Rhine, at the lower Side of the Town, notwithſtanding it is not delineated in the French Plan: He has not, however, been guilty of the ſame Omiſſion at the upper Side of the Town, having given three Batterdeaux to the great Ditch before the Angle of the Baſtion B. I muſt confeſs I am at a Loſs to diſcover the Uſe of this Cluſter of Dams; nor is the Intention of them, perhaps, eaſy to be diſcerned, unleſs one were upon the Ground. I ſhould be apt to imagine, that the Batterdeau at I, which runs from the Extremity of the Glacis of the land Front B E, to the Extremity T of the covered Way of the long Side, would be ſufficient, with a Sluce, to ſupply Water to the great Ditch of the land and river Fronts, and to retain it when the Rhine is low; a Batterdeau being alſo ſuppoſed to be at the lower Extremity of the covered Way of the long Side; for the former is covered by the Extremity of that covered Way from being battered from the oppoſite Shore, which covered Way is of too great a Thickneſs, and too remote

from the other Side to be breached thence by Cannon; and the little rounding of Land x, which juts out towards the River, affords an Opportunity of covering it from any Battery that may be raiſed on the hither Bank of the River; and the Batterdeau of the lower Side may be more retired within the Extremity of the covered Way; and the river Bank on that Side is greatly commanded by the Redout R. But if the great Ditch within the covered Way of the long Side is intended to ſerve as a Harbour for Boats, there muſt be one Batterdeau at the Extremity of the ſaid covered Way, at the higher Side of the Town; the Ditch of the other Extremity being left open for the Admiſſion of Boats, and having an iron Chain to fix a-croſs it occaſionally; and a Batterdeau muſt be run a-croſs the great Ditch of each of the collateral Fronts, to the Angles of their Demibaſtions which terminate at the Bank of the River.

205. The Ravelin of the long Front ſeems intended to command the Extremities of its covered Way, which are at too great a Diſtance from the Fire of the Muſquetry of the Flanks of that long Front; and to render the Communication between the Curtain of that Front, and the oppoſite covered Way and Bridge more eaſy.

206. The covered Way of the long Side, beſides the Advantages already mentioned (198) that ariſe therefrom, ſerves to cover the Stone Wall of the river Front, and of the Faces of the river Baſtions that regard the Land, and the Batterdeaux of the great Ditch, from being breached or much damaged from the oppoſite Shore: It alſo covers the Flanks of the adjacent Baſtions that defend theſe approachable Faces of the river Baſtions, from being commanded and ſilenced from thence by Counterbatteries.

207. The Hornwork in the Rhine not only flanks well and cloſely the Works on the other Side of the River, but alſo covers the Bridge of Boats of the Rhine, ſo as that it cannot be hurt by the Batteries of the Enemy, except at its Extremities cloſe to the covered Way of the long Side, and at the Gorge of this Hornwork, from oppoſite Sides of the River, where it is moſt eaſily repaired: The right Wing of that Work alſo commands the Iſland v on the higher Side of the Town, which might otherways be of Uſe to the Enemy.

CHAP. IV.

Another defenſive Model for a river Situation, with the Extremities of the long Side next the River, fortified in ſuch a Manner, and the covering Works on the oppoſite Bank ſo adapted thereto, as to ſuit any Length whatſoever of a river Front.

208. THE preceding Model will not yet be ſufficient to give a thorough Knowledge of the Manner to be obſerved in fortifying by the Sides of large Rivers. It generally happens, that Towns ſituated on large navigable Rivers, have the Side next the River of much too great a Length to be contained in one common Front of Fortification: I have, therefore, conſtructed this Model, Pl. xiv. with the long Side next the River, fortified ſo as to ſuit any Length of Side whatſoever in the like Situation, and with covering Works properly adapted thereto; the Fronts towards the Land being fortified on the ſame Principles as Mr. Vauban's of Hunningen.

209. This Enceinte is conſtructed on an irregular Pentagon, conſiſting of 4 Sides of a true Hexagon, towards the Land, and the Chord of the Segment of the Circle in which theſe are inſcribed; which laſt forms the long Side to the River; and the River is 100 Toiſes in Breadth.

210. On taking a View of this Plan, the Manner and Intention of the Conſtruction of the Works on both Sides of the River are, at once, conſpicuous. On the Extremities of the long Side of the Place, are conſtructed two ſpacious Demibaſtions A, B, with a Batterdeau, or Dam of Maſonry (K), running from the ſaliant Angle of each to the oppoſite covered Way, to retain the Water of the great Ditch when the River falls low in droughty Seaſons: Within theſe large Demibaſtions are conſtructed, upon the long Side, two ſmall flat Demibaſtions C, D, with an intermediate Curtain, which furniſhes a Paſſage from the River to the little Baſon or Key F, incloſed within the Rampart; which Curtain is defended by the Flanks of theſe flat Demibaſtions C, D; whoſe Capitals afford each two ſpacious Batteries, conſiſting of one high (D), and one low (T), to flank and command the Epaulments or Screens O O, before the Extremities of the long Side, the Capitals of the great Demibaſtions A, B, the exterior Sides of their Batterdeaux, the intermediate running Ditch, and the Margin of the River above and below the Town; which Batteries cannot be commanded by the Cannon of the Enemy, there being no Place to raiſe Counterbatteries againſt them; and the Angle T, which is formed by the Capitals of the flat and extreme Demibaſtions, is ſeen from the ſmall Flank or Retreat S, in the Capital of the latter.

211. The Screens o o before the Extremities of the long Side, are ſuppoſed to be of ſolid Maſonry under Water, and above Water to conſiſt of Earth reveted and creſted with faſcine Work. The outward Extremity (L) of the Screen on the higher Side of the Town would require, however, to be alſo of ſolid Maſonry to the Height of 5 or 6 Feet above the Surface of the River, to divide and reſiſt better the impelling Stream in high Floods: I alſo ſuppoſe a large Break-water of ſtrong Beams well jointed, to be planted a little above it at N, to weaken, in ſome meaſure, the Force of the Current againſt the Screen and Capitals of the Demibaſtions at the higher Extremity of the long Side; and againſt the river Bank which terminates the Creſt of the Glacis and the covered Way. Theſe Screens (o o) cover the Revetements of the Capitals and Faces of the Demibaſtions A, B, and the Batterdeaux of the great Ditch, ſo as that they cannot be breached or much damaged by the Enemy's Cannon from the oppoſite Shore; as well as the Flanks P, P, which command the great Ditch of the Faces of theſe Demibaſtions. I have not given the Screens a covered Way, which would induce a conſiderable Expence; beſides, that it appears to me wholly unneceſſary, all except ſome Advantage that might ariſe from an interior Breaſtwork at their outward Extremities (198); and the Expence even of this would ſcarce be compenſated by the Advantage thence ariſing; beſides the Riſque of the Enemy's deriving ſome Advantage from the Breadth which muſt be given, in that Caſe, to their outward Extremities; nor would ſuch a covered Way be proper, in this Model, as the ſeveral approachable Fronts would be thereby rendered more unequal, in point of Strength. It muſt alſo

be obſerved, that if there is not naturally a Depth of Water of four or five Feet on both Sides of the Screens o o, and for ſome Way beyond their outward Extremities, when the River is at the loweſt, it muſt be dug, and a proper Depth given it by Art. The great Ditch of the Place has a Communication with the River, by means of a ſubterraneous Aqueduct which runs in the Direction of the pointed Lines x, and has a covered Sluce.

212. As it would amount to too great an Expence, to raiſe, on the oppoſite Shore, one continued Work of ſufficient Extent, to cover the Works on the Extremities of the long Side of the Place from the direct and ricochet Batteries of the Enemy, the principal covering Work may conſiſt of a Crown or Horn-work; and from the Wings thereof a Chain of reveted Lunettes, or Redouts, E, G, H, R, may be run out along the Bank, with a covered Way, until they extend to a due Diſtance, ſo as to cover the Inſide of the Breaſtworks of the Faces of the great Demibaſtions A B, at the Extremities of the long Side, as in the Model before us: By means of theſe wide-extended covering Works the Bridge on the River will alſo be better ſecured. The Hornwork, and the Lunettes have their Gorges cloſed up with a thin Wall of Maſonry, that is eight Feet above the Surface of the Water, to prevent Surprizes, which, however, doth not hinder them from being ſufficiently commanded by the oppoſite long Side A B.

213. The Fronts of the Place towards the Land are fortified on the ſame Principles as thoſe of Hunningen (194 to 200); only in this it may be obſerved, that the ſeveral Baſtions of the Enceinte are nearer on a Ballance, in point of Strength, becauſe the outward Extremities of the Screens

(o o) have no covered Way with an interior Breaſtwork; the Ravelins of the Fronts which terminate at the River will therefore alſo be weaker than thoſe on the land Side (198). So that the ſeveral approachable Fronts, in this Conſtruction, will be nearly on an equal Foot, in point of Strength, their Conſtructions being ſimilar, and the invironing Ground being ſuppoſed plain and homogeneous. There was a Neceſſity, however, of advancing ſmall Lunettes, to guard the Batterdeaux (M) at the Extremities of the Fore Ditch, and conſequently before the other Baſtions, to preſerve a juſt Ballance: Nor will it be poſſible to cut off any one of the three Lunettes before the land Baſtions by their Gorges, by means of double Saps, on account of the Fore Ditch which runs within them; nor thoſe before the Demibaſtions A B, becauſe of their Proximity to the covered Way and interior Works: And the Breaſtworks of their Gorges, which are thin Walls of Maſonry, may be ruined by Fougaſſes, when the Beſiegers are forced to abandon them. The three former Lunettes have their covered Way on a Level with the Field; and the Space included between their covered Way, their proper Ditch, and the Fore Ditch, is ſuppoſed to be cut down nearly to the Level of the Water, that it may be more difficult for the Enemy to eſtabliſh Lodgements therein, and that theſe Pieces and their Ditches may be well commanded from the interior Works, without any Interruption; and by their being advanced without the Fore Ditch, they will cover the Retreat of great Sallies. The Lunettes before the Demibaſtions A B are retired cloſe under the Command of the interior Works, and have the Fore Ditch in their Front, that they may be leſs liable to Surprizes, which might otherwiſe be attempted, with a Deſign to poſſeſs the Sluces of the Fore Ditch.

CHAP. V.

A Model of a Fortreſs ſituated in a low champain Country, with a ſmall River running through it, and the river Fronts properly fortified, and furniſhed with Batterdeaux and Sluces, ſo as to enable the Beſieged to obtain conſiderable Advantages by means of the River, during a Siege, firſt by inundating the circumjacent Field, and afterwards by conveying the River through the great Ditch, on the Side of the Enemy's principal Attack.

214. WHEN a Fortreſs, ſtanding in a low champain Country, has a ſmall River running through it, the Front by which the River enters, and alſo that by which it makes its Exit, muſt be fortified in a particular manner, ſo as to give the Beſieged an Opportunity of making the beſt Uſe of the Advantages that may be obtained by means of the River, during a Siege; firſt, by inundating the circumjacent Ground; and afterwards, by making the River run through the great Ditch, on the Side of the Enemy's principal Attack.

215. In ſuch a Situation, the River being ſuppoſed navigable below the Town for Boats, or ſmall flat-bottomed Veſſels, as at Breda, it will be proper to have an iron Boom to lay acroſs the River every Evening at the ſhutting of the Gates, at the Ouverture of the Rampart of the Place (Pl. XV. E), where it makes its Exit out of the Town, to guard againſt Surprizes, and to hinder the Admiſſion of Boats in the Night. And during a Siege it will alſo be neceſſary to have a Boom or Barrier of Wood to fix acroſs the River, on the higher and lower Sides of the Town, at the outmoſt

Barriers, the better to guard againſt Surprizes: And there ought always to be one iron Grate at the great Opening N of the Rampart, where the River enters; and for more Security there may be alſo one at the outmoſt Barrier, to intercept Trees, or whatever elſe, by being waſhed away from off the Banks of the River by the ſwelling Stream, after heavy Rains, and ſwept along with the Flood, might be liable to chock up the Paſſage of the River through the Rampart; and alſo to contribute to diſappoint Surprizes.

216. In order, then, to obtain the Advantages ariſing to the Beſieged from the particular Conſtruction of the river Fronts A B, C D, the Ravelin, I am of Opinion, of the Front A B, by which the River enters, ought to have its ſaliant Angle inverted, ſo as to form two pretty large re-entring Faces, after the Manner of a ſingle Tenaille, with an Opening in the re-entring Angle, and through the Gorge of the Ravelin, to conduct the River into the Ditch of the Curtain of the Place, that it may from thence run through the opening of the Rampart; two collateral Batterdeaux, (G, C) which I ſuppoſe to run from the interior Extremities of the Ramparts of the exterior Faces of this tennailed Ravelin to the Curtain, confining and directing its Courſe that Way. Each of theſe Batterdeaux (G, C), which muſt not be raiſed to more than three Feet and an half above the Surface of the Water of the great Ditch, muſt have a covered Sluce in their Extremities which terminate at the Rampart of the Curtain: A Batterdeau (H) muſt alſo run from each of the ſaliant Angles of the tenailled Ravelin to the Counterſcarp, in the Direction of its re-entering Faces, which muſt be of a good Thickneſs, and raiſed to the Height nearly of the Creſt of the Breaſtwork of the covered Way, to reſtrain Innundations,

tions, with a Sluce in the re-entering Angle of the Tenaille, to raiſe them by daming up the River, and obſtructing its Courſe by that Channel. And when the Aggreſſors are ſuppoſed to have carried their Approaches to the Foot of the Glacis through the Inundation, or rather after they have drained the inundating Water, there being ſcarce any artificial Inundation that may not be drained, if the Channel of the River below the Town is approachable; ſometimes, indeed, it may be liable to be damed up again at ſome Diſtance below the Town, as at Fort Crevecœur, where the River Deeſe, which is formed by the Junction of the Rivers Aa, and Dommel, after paſſing through Boiſleduc, is liable to be damed up by the Flood-gates there, juſt before it diſcharges itſelf into the River Maeſe; in that Caſe ſuch an Inundation can only be drained by running new Channels for theſe ſmall Rivers all the Way into the Maeſe, above and below that Fort, when the Maeſe is low, and does not contribute to the Inundation, which cannot be done without immenſe Difficulty and Labour, by reaſon of the great Extent of theſe Inundations, which may be formed round Boiſleduc, and over a conſiderable Extent of the circumjacent Country, eſpecially towards the Bank of the Maeſe; which will render the Approach of the Enemy to that River, with Intention of draining the Inundation, very difficult, and eaſy to be defended; when the Beſiegers then, I ſay, have carried their Approaches to the Glacis, the next Uſe to be made of the River, and which is not of the leaſt Importance, is to make it run through the great Ditch of the Front againſt which the principal Attack of the Enemy is directed; which is done, (the Front C D, by which the River makes its Exit out of the Town, being alſo ſuppoſed to be conſtructed in like Manner as the former, with reſpect to the Ravelin and Batterdeaux) by letting down firſt the Sluce of the Rampart of the Place (N) where the River enters, then raiſing the Sluce of the Ravelin (K) which occaſions the Inundation, which is now ſuppoſed to be diſcharged, and then the Sluce of the interior Batterdeau of the Ditch of the Curtain, on the Side of the principal Attack, and alſo the Sluce of the interior Batterdeaux of that Side in the lower river Front (C D); by which means the River will be conveyed by the great Ditch, on that Side of the Fortreſs, into the Ditch of the Curtain of the lower river Front, and from thence into its proper Channel below the Town; and if the Enemy, conſcious of this, ſhould carry on the Attacks on both Sides of the Town equally, the Sluces of both the interior Batterdeaux (G, C) of the Curtain of the high river Front, and alſo thoſe of the low river Front may be opened together, that of the Rampart (N) being kept ſhut; by which means the River will run through the great Ditch, partly on one Side, and partly on the other, and about the whole Circumference of the Body of the Place.

217. It would be wholly unneceſſary to give a Detail of the Advantages which will accrue to the Beſieged, by means of a running Ditch, by difficulting, in a very conſiderable meaſure, the Paſſages of the great Ditch; which are already recited in the moſt particular and diſtinct Manner, in Mr. Vauban's Book of the Attack and Defence. It will be neceſſary that the River paſs through the Rampart of the Ravelin, and of the Place, on the high Side of the Town, under ſtrong and ſpacious Arches, rather than by an open Coupure; that the Sluces, by ſliding down cloſe to the

Sides, or in the Middle of theſe Arches, may be more ſecure from Bombs.

218. It will be neceſſary to give a ſmall concealed Sluce to each of the Batterdeaux at the ſaliant Angles of the tenailled Ravelin K of the high river Front, to allow ſome Part of the River to paſs by the great Ditch, and by the Sluces of the lower Front into the lower Channel, in high Floods of the River; that the Arches, or Ramparts of the Ravelin, and the Place, at the higher Front, may not ſuffer any Damage thereby. It will alſo be proper to have a ſmall Traverſe (M) of Maſonry, in the mid Channel of the River, before the outmoſt Barrier, to weaken, in ſome meaſure, the Force of the Stream before it enters the Works; and alſo to cover the Sluce of the Ravelin from the Batteries of the Enemy in the Field. Two Batterdeaux ought alſo to interpoſe between the Extremities of the Fore Ditch, and the Channel of the River above and below the Town: Thoſe (P P) before the high river Front are to be ſlight, and no higher than the Surface of the Water of the Fore Ditch; being intended to direct the River into the Works, and to prevent the Enemy from diverting ſome Part of the Water thereof, by cutting a Canal from the Fore Ditch into the lower Channel (Q) of the River: Thoſe (S S), again, before the low river Front, at the Extremities of the Fore Ditch, muſt be made ſtrong, and as high as the Creſt of the ſmall Dam of the River, to reſtrain the Inundation, and reſiſt its Preſſure. There muſt alſo be a covered Sluce (O O) in the covered Way before each of the exterior Faces of the Ravelin of the high river Front, for a Communication between the Fore Ditch and the great Ditch.

219. The Front (A B) at the Ingreſs of the River muſt be ſtronger than any of the other Fronts, (excluding the low river Front) by ſo much as it is weakened by the Batterdeaux, which, however, is very little, and in proportion to the Advantages accruing to the Beſieged, by means of the running Moat: The low river Front muſt alſo be ſtronger than theſe other Fronts, but leſs ſo than the high one: The Figure before us, Pl. xv. exhibits two Segments of the Circumference of ſuch a Fortreſs, fortified agreeable to theſe Conſiderations.

220. That the Method of keeping up theſe Inundations may be rightly underſtood, it is neceſſary to know, that in low flat Countries, as the Netherlands, where a ſmall River, ſuch as we have ſuppoſed above, paſſes thro' a fortified Town, its Borders below the Town, and generally throughout its whole Courſe thence, till it diſembogues itſelf into the Sea, or into ſome great River, are raiſed above the Level of the Field to prevent its overflowing the Country, when ſwelled by heavy Rains, and probably alſo to favour artificial Inundations; and alſo above the Town, except within Cannon-ſhot of the Place, where its Banks are generally lower; with Intention, I ſuppoſe, that it may inundate frequently the Field on either Side, and in the Circumference of the Town, and make theſe Fields, and a conſiderable Part of the invironing Ground of the Fortreſs, marſhy; and the Water that runs from thence to the Banks of the lower Channel, being excluded by the Dams on each Side of it, ſtagnates on the bordering Fields before the Place, occaſioning them to be oozy and marſhy, and generally covered with large Tracts of ſtanding Water; which frequently extend to a conſiderable Diſtance below the Town, and ren-

ders the Approach of the Enemy to the Dams of the lower Channel, very difficult; but ſtill more ſo when the Inundation is formed, which may be made to riſe as high as the Creſts of the Dams of the lower Channel, if it doth not firſt ſpread a conſiderable Way over the adjacent low Country, and meet with little Drains, or other Outlet, that will not ſuffer it to riſe higher. It is nevertheleſs certain, that the Enemy will generally find means to approach, and cut the Dams of the lower Channel when the collateral Inundations are not very extenſive, unleſs theſe Dams are guarded by a Chain of ſmall Forts or Redouts: The Marſhes, however, which are occaſioned by the ſtagnating Water, will add greatly to the Strength of the Place.

221. The Beſieged, before they open the Sluces of the Batterdeaux of the Curtain of the high river Front, in order to let the River run by the great Ditch, may ſuffer the Water to dam up as high as the ſharp Creſts of theſe Batterdeaux; which will occaſion the Stream to ruſh in a greater Torrent againſt the Works of the Enemy in the great Ditch, which are ſuppoſed to be begun before the Sluces are opened, that the Effect of the Current, by being more confined, may be greater. It may be alſo obſerved, that the River may be made to run by the great Ditch without diſcharging the Inundation.

222. At Breda, the ſmall Rivers Merk and Aa, do run into the great Ditch cloſe by the left Flank of the Ravelin; and the Batterdeau of that Side is carried from the reentring Angle of the Counterſcarp to the Curtain; and there are no exterior Batterdeaux, as in our Method: For which Reaſon the Engineers, who had the Direction of the Inundations of the invironing Ground of that Fortreſs, in

the End of the late War, were under a Neceſſity of filling up the Channel of the River, between the left Flank of that Ravelin and the oppoſite inward Place of Arms, by a large Dam of Earth, in order to exclude the River, and lay the circumjacent Field under Water: For the Batterdeaux in the Ditch of the Curtain were too weak to withſtand the Preſſure of the Water, and too low to ſuffer it to riſe to a ſufficient Height; and if theſe Batterdeaux had been at firſt made higher they would have intercepted, in ſome meaſure, the Fire of the Flanks of the Demibaſtions of the river Front againſt the great Ditch of the Faces of theſe Demibaſtions. In the Middle and on the Top of the Dam abovementioned, they planted a Sluce, which could anſwer no other Purpoſe than to ſupply a Mill, which is ſituate behind the great Sluce of the Rampart of the Place (N), with Water during the Inundation; for the Bottom of the Caſe of it was higher than the Level of the running Stream before the Inundation was raiſed: Therefore the Enemy might, in one Night, by carrying a Canal from the Channel of the ſmall River Aa, (which runs into the Fore Ditch before the Angle of the Baſtion, to the Left of Antwerp Port) down into the lower common Channel, after cutting the Dam of this latter on that Side, to evacuate the ſtanding Water on its Border, make a Drain that would not only evacuate the Inundation, but alſo divert the whole of the running Water of the two Rivers Merk and Aa, by that new Channel, there being no Batterdeaux to cut off the Communication of theſe Rivers with the Fore Ditch (118); the Surface of whoſe Streams, as ſoon as the Inundation was drained, would ſink below the Bottom of the Sluce of the new earthen Dam.

223. Theſe Engineers did alſo run a broad Dyke, from the ſaliant Angle of the inward Place of Arms to the Right of the Ravelin before Antwerp Port, to a ſmall advanced Piece of a covered Way, in order to inundate the Field before the Front to the Right of Antwerp Port, and alſo the Field before the ſeveral Fronts that are included between the Ginneken and Buſh-Ports; and the better to promote the Inundation of the Field before theſe latter, they filled up the Fore Ditch under the Draw-Bridges at the Cauſeys leading into theſe Ports; ſtill maintaining, indeed, a Communication between the collateral Portions of the Fore Ditch, by Sluces planted in the Places of Arms within theſe Cauſeys, in Channels that were made for them, whoſe Extremities terminated in the Fore Ditch to the Right and Left of the Cauſeys; and they threw up ſeveral little Dams in the Field before theſe Fronts, and along the exterior Border of the Fore Ditch, to retain ſo many Tracts of Inundation, which proceeded from the great Inundation before the high river Front; which Dams, however, might have been very ſoon and eaſily opened, and with little Danger, in the Night; and the whole amaſſed Water ſuffered to run into the great Inundation, and from thence by the Fore Ditch into the new Channel made by the Beſiegers, and into the lower common Channel of the Rivers. Yet ſome Advantage would ariſe, in conſequence of the Inundations, by the Ground which was laid under Water being thereby rendered ſoft and oozy; which Advantage however will, I preſume, be fully counterballanced by the Advantages that might accrue to the Enemy from the Fore Ditch's having been filled up at the Cauſey before Ginneken Port; and by means of the broad Dyke which was run over the

Fore Ditch at the inward Place of Arms before Antwerp Port; and of the Dams before the Fronts to the Left of Ginneken Port; which latter would cover the Aggreſſors from the Fire of theſe Fronts, after diſcharging their included Water; beſides the Advantages they might reap from the Conveniency of the high Ground of the Glacis of each of the two advanced Pieces of a covered Way to the Right of Antwerp Port; which Ground was before very judiciouſly cut down almoſt to the Level of the Water of the Fore Ditch (97); and theſe advanced detached covered Ways might have been very eaſily forced, after draining the Inundations; and eaſily lodged on, by reaſon of their great Diſtance from the interior Works.

CHAP. VI.

Of Forts and Batteries for the Sea Shore.

224. THE Situation of Forts and Batteries for the Sea Shore, for commanding Harbours, or Places of landing, and the Channels leading into them, muſt be determined chiefly by the Situation and Courſe of theſe Channels with reſpect to the Shore, or ſmall adjacent Iſlands, Rocks, or Keys, or Points of Land projecting into the Sea, that they afford convenient Ground for raiſing Batteries on that will moſt effectually command the ſaid Channels, and preſent, at the ſame Time, a conſiderable Front to the Harbour.

225. Our Batteries on the Sea Coaſt are generally made with very low Epaulments, and ſometimes wholly unſcreened, and open towards the Field; which Mr. Muller, Profeſſor

of Artillery and Fortification in the Royal Academy at Woolwich, has very juſtly found Fault with; and has recommended, not only higher Epaulments, but alſo to cover the Platforms over Head with an arched, or flat Roof, to guard againſt the Fire of Swivels and ſmall Arms from the Maſt Heads of Men of War. A Breaſtwork may alſo be raiſed 4 or 5 Feet above the Roof of ſuch a covered Battery, for Muſqueteers; or there may be a double Battery, the Roof of the lowermoſt making the Platform of the upper one. I muſt own, however, I cannot approve of theſe double Batteries, becauſe the ſecond battering Story is more expoſed to the Fire of the Ships, and fires with much leſs Certainty againſt the Aggreſſors than the low Battery, whoſe Cannon being once levelled in a Poſition parallel to the Surface of the Water, will always be readily pointed, and ſcarce ever miſs hitting the Object.

226. But as the Expence of theſe vaulted Batteries muſt be conſiderable, and as the Columns, or Pilaſters that ſupport the Roof may incumber, in ſome degree, the Gunners, ſo I am of Opinion, the following Method will be preferable, becauſe it will anſwer the End required of Batteries or Forts on the Shore, at leaſt, as effectually as the former, and may be conſtructed at a leſs Expence.

227. If the Situation of the Battery, with reſpect to the Harbour, or Road, or Channel it commands, is ſuch, and the anchoring Ground convenient, ſo as to make the Front or Fronts of it towards the Sea liable to be enfiladed from the Maſt Heads of Ships of War; in that Caſe, high Traverſes muſt be raiſed at the Extremities of theſe Fronts, and alſo ſome intermediate Traverſes, if the Fronts are long; which ſhall overtop by 3 or 4 Feet the Wall, or Epaulment

ment of this Battery; which Epaulment muſt be carried up to the Height of 10 Feet at leaſt, the Platform being nearly on a Level with the Surface of the Sea at high Water; and the Ambraſures muſt be cloſed at Top, and made by way of Port-holes, with their narrow Extremities towards the Sea; and the Ports may be provided with Blinds, ſince theſe will have a good Effect, not ſo much to intercept the Fire of ſmall Arms, as to leſſen, in a great meaſure, the Panic which is liable to ſeize the Gunners, at the Sight of the intenſe and inceſſant Fire that is directed againſt them from the Sides of the aſſailing Men of War, which poſſeſſes them with a Notion of being every Moment in the utmoſt Danger while they are oppoſite to the Gun-Port, or Ambraſure, loading or pointing the Cannon; altho' their Danger, in Batteries conſtructed in this Manner, and with narrow Port-holes, is really inconſiderable; the Fire of the Ships of War, at the Diſtance at which they generally bring to before Forts or Batteries, *viz.* between 150 and 300 Yards, being vague and uncertain. This Height of Epaulment will be ſufficient, with the Addition, occaſionally, of two Feet of Earth on its Creſt well beat, and reveted and creſted with Sod, to cover the Platform from being plunged into by the Swivels and Muſquetry of the Tops, even ſuppoſing the aſſailing Ship of War only 90 Yards diſtant from the Battery, and the main Top 90 Feet above the Sea, notwithſtanding the Platform is on a Level with the Surface of the Water.

228. It may not be improper to obſerve, that it will not always be neceſſary to make the Batteries of the Sea Shore defencible on the Land Side; for, ſuppoſe the Mouth or Channel leading into a Harbour of great Importance, is

required to be fortified ſo as to oppoſe an extenſive battering Front to the Sea; in that Caſe, a ſmall high defenſible Fort may be conſtructed in the Middle of the moſt convenient Situation, with one Platform only; which, however, muſt be raiſed to a good Height above the Level of the Field, that it may not be forcible; and from the Right and Left thereof, two Batteries with low Platforms may be run out along the Shore, to the Extent that is required, ſo as that theſe low Batteries ſhall have their exterior Sides flanked, and their Platforms ſeen into and commanded from the intermediate Fort; the Walls of theſe Batteries being conſtructed as abovementioned (227), and with Traverſes, according as they are liable to be enfiladed; by this means we ſhall have an extenſive and moſt effectual Battery that will be in no Danger of being forced by a ſudden Attack, and at a much leſs Expence, and that will anſwer the Purpoſe better than if the whole were one high unforcible Fort; by reaſon the Fire of the collateral low Batteries cannot fail of having the beſt Effect, their Platforms being on a Level with the Surface of the Sea at high Water.

229. Again, if we ſuppoſe a ſmall Iſland to have one Harbour, and five or ſix little Bays where Troops may be landed in Boats; it is not to be imagined, that the Government or Prince whoſe Property it is will be at the Expence of raiſing a defencible Battery or Fort at each of thoſe Places of landing, unleſs the Iſland is of very great Importance indeed: It will be ſufficient to raiſe one Fort for commanding the Harbour, with collateral low Batteries, if found neceſſary; and to throw up before each of theſe Bays, in time of War, a Battery of Earth, properly reveted, and bound with Faſcines,

cines, which may be cloſed on the Side of the Land by a ſmall Retrenchment; and it may be reinforced and ſuſtained, and the Bay more effectually commanded by collateral Retrenchments that ſhall flank the Battery, and embrace the ſmall Bay, or that Part of it where the Enemy can moſt conveniently land; the Ditches of theſe Retrenchments, and before the Battery, being well palliſadoed.

230. Where there is deep Water very near the Shore, whereon a Fort is to be raiſed for commanding a ſmall Harbour, or any Place of landing, it will be of the utmoſt Conſequence, tho' contrary to the common Practice, to raiſe the Fort at ſome Diſtance from the Verge of the Water, if the Ground will admit of it, ſo as that a Ship of the Line ſhall not be able to approach within three hundred Yards of the Fort; for the Uncertainty of firing from Ships of War increaſes in a very great Proportion, as the Diſtance is enlarged, by reaſon of their inceſſant Motion, while Forts and Batteries erected on the firm Land are void of that Inconvenience: The Uncertainty of the Fire of the former, with reſpect to that of the latter, is ſtill conſiderably augmented, inaſmuch as the Portholes of Forts conſtructed in our Manner, which are the only Objects of the Fire of the aſſailing Ships, are ſmaller than the Hulls and Rigging of theſe Ships, the Objects of the Fire of the Artillery of the Fort. Such a retired Fort may have Coffers, or covered and interred loop-holed Lodgements before its ſea Fronts, to command more effectually the Beach, and impede any landing of Troops from the Ships of the Enemy. But when a Fort is intended to command a Channel leading into a great Harbour, it may be erected nearer the Shore, eſpecially if the Channel is broad, that Ships which attempt to paſs it may run a greater Hazard.

231. The

231. The Forts and Batteries of the Sea Coaſt, temporary ones excepted, ſhould always have the Walls or Epaulments of their Fronts which oppoſe the Sea, wholly of Maſonry, about the Thickneſs of eight or nine Feet at the Bottoms of the Gun Ports; not only that they may admit of Ports, but likewiſe that theſe Ports may allow of being made ſmaller, and conſequently leſs liable to have their Cannon diſmounted and diſabled, and the Gunners killed and wounded by the Fire of the aſſailing Ships: I ſay then theſe Walls ought to be wholly of Maſonry, and as thin as is conſiſtent with the Uſe of them; for the thinner the Wall is, by ſo much the more perpendicular and horizontal Space upon the oppoſite Sea will fall within the Range or Bearance of its Cannon, with Port-holes of equal Dimenſions; ſo that a ſmall Port-hole in a Wall of Maſonry will take in as much Space within the Range of its Cannon, as a Port-hole, or Ambraſure of much greater Dimenſions where the Epaulment conſiſts of Earth reveted with Maſonry; which therefore will require to be five or ſix Feet thicker than the former Stone Wall, and eight or nine Feet thicker, if it is not reveted to the Creſt of the Epaulment; and the Chance of hitting within theſe ſmall Gun Ports will be very little, eſpecially as their narrow Extremities are ſuppoſed to be turned outwards; nor can the Ruins of the Wall ever be made to fly inwards among the Gunners, by the impelling Shot, unleſs the Ball hits upon the exterior Border of the Port-hole, or on the interior Surface of it within three Feet of the exterior Border (232); which may alſo happen in Batteries of Earth that are reveted with Maſonry: Nor will this Wall ever be in Danger of being deſtroyed, or breached by Ships of War; which is well known to thoſe who have

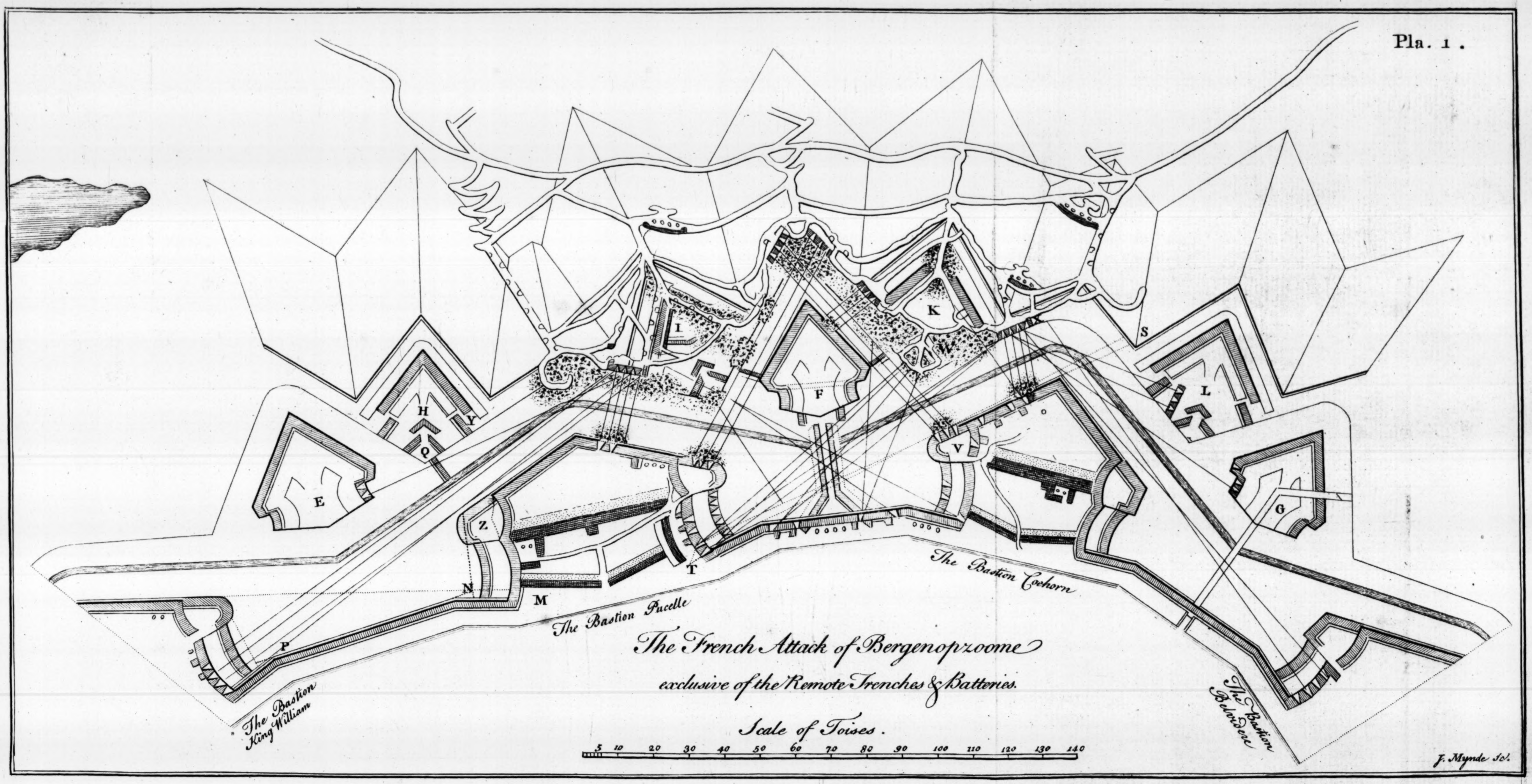
been at the attacking of Forts from the Sea, and which any one muſt be convinced of who has ever ſeen the ſlow Effect of three or four heavy Cannon firing by Vollies, from the Counterſcarp of the great Ditch, againſt the Wall of the Face of the oppoſite Baſtion, at the Diſtance of 32 Yards, and hitting every Time nearly in the ſame Place; ſince Men of War very ſeldom bring to before a Fort nearer than 150 Yards; and every one knows the Uncertainty of firing at a ſmall Mark, at that Diſtance, from the Side of a Ship that is continually in Motion from the inceſſant Agitation of the Sea, even in the moſt perfect Calm, and which is increaſed by the Shocks occaſioned by the recoiling of the great Guns: So that the Bullets that are impelled from the Battering Sides of Ships of War, againſt Batteries conſtructed in the Method abovementioned, on the firm Land, will be all to little Purpoſe, except the few that chance to enter the Ports. Theſe Forts may, on the Land Side, be conſtructed with Ramparts and Breaſtworks of Earth reveted with Maſonry, and with common Ambraſures.

232. The Port-holes of the Sea Fronts of theſe Forts muſt be made as narrow, for the Reaſons already mentioned, as is conſiſtent with the Uſe of them: The Dimenſions of ſuch a Port may be as follows; the Thickneſs of the Wall being ſuppoſed eight Feet at the Bottom of the Port: The horizontal Breadth of its interior wide Extremity may be ſix Feet; its perpendicular Height three Feet; the Slope of the Bottom of the Port from the interior to the exterior Surface of the Wall one Foot; the Perpendicular Height of the exterior Mouth of the Port three Feet; its horizontal Breadth alſo three Feet; and the horizontal Breadth of the Port, at three Feet from its exterior

Border, two Feet ſix Inches. By contracting it in this Manner at the Diſtance of three Feet from its exterior Ouverture, and afterwards making it ſlope a little outwards to either Side, the Border of its exterior Mouth is conſiderably ſtrengthened, and when a Ball ſtrikes againſt the exterior Edge, the Pieces of Stones will be leſs apt to fly inwards; nor does it in any degree abate of the Extent of the Bearance of the Cannon: And, indeed, I am inclined to believe, that two Feet and an Half will be ſufficient for the horizontal Breadth of the exterior Mouth of the Port-hole, which may be contracted inwards to two Feet, at the Diſtance of three Feet from the exterior Border, and from thence to the interior Edge to ſlope off to five Feet, or five Feet and an Half horizontal Breadth. I know no Objection of any Conſequence that this Method of inverting the broad Extremity of the Ambraſure, or Gun Port of ſuch a Fort is liable to; the Extent of its Bearance will be ſufficient, and the Advantages gained thereby are conſiderable. For if we ſuppoſe two Port-holes, one with its narrow Extremity turned outwards, and the other with its broad Extremity, both being ſuppoſed to be conſtructed as above, I affirm there will be ſo much leſs Chance to diſmount, or diſable the Gun of the firſt Port, whoſe exterior Mouth is narrow, and to kill and wound the Gunners who ſerve it, than there is to diſmount or diſable the Gun of the latter, and annoy the Gunners, by how much the Dimenſions of the narrow exterior Mouth of the firſt are inferior to thoſe of the wide exterior one of the laſt: For in the Caſe of the firſt, its Gun cannot be diſmounted, unleſs the Bullet from the Cannon of the Enemy enters its exterior Mouth, or ſtrikes againſt the interior Surface of it: And in the Caſe of the other alſo, which has its broad Extremity outwards, every Ball that comes within the Verge of its ſpacious exterior Mouth will, as in the firſt, either diſmount its Gun, or fly in thorough the Port-hole; for if it ſtrikes obliquely on any Part of the interior Surface thereof, it will be reflected at the ſame Angle, and diſable or diſmount the Port-gun, or fly quite in thorough the Port; beſides the Pieces of Stones which it will ſtrike off the interior Surface, and drive inwards among the Gunners.

FINIS.

Pla. 1.



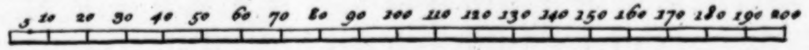
The French Attack of Bergenopzoome
exclusive of the Remote Trenches & Batteries.

Scale of Toises.

J. Mynde sc.

Pla. II.

A Scale of Toises.



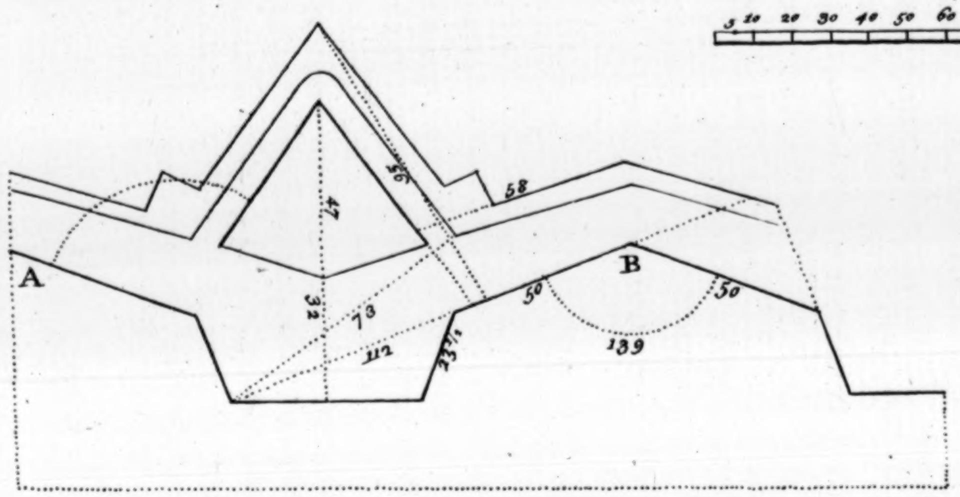


Fig. 1.

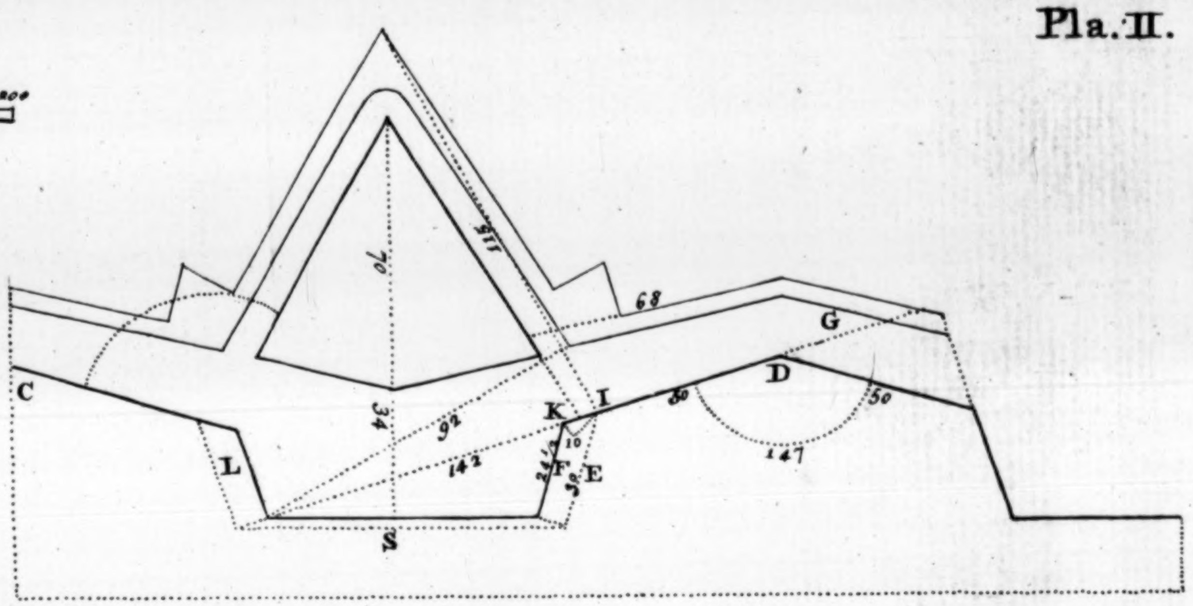
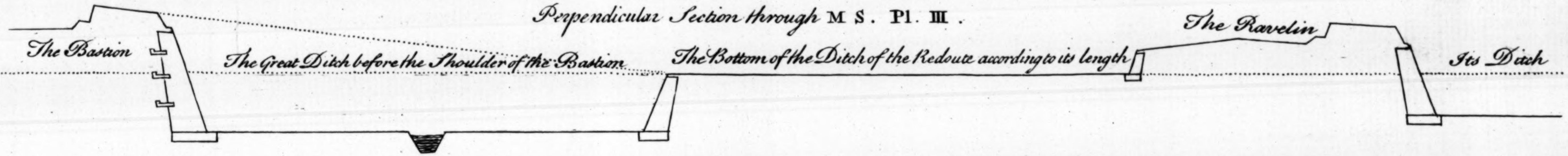
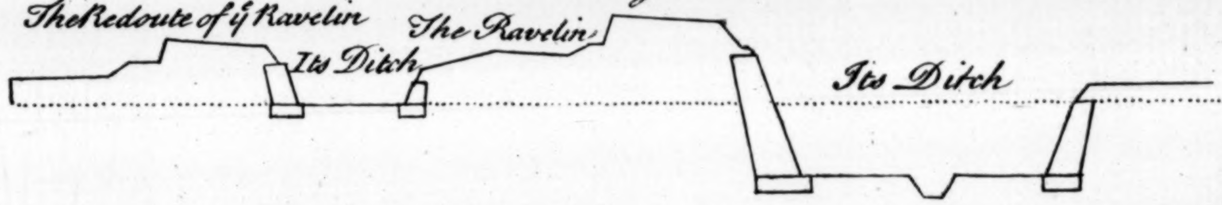


Fig. 2.

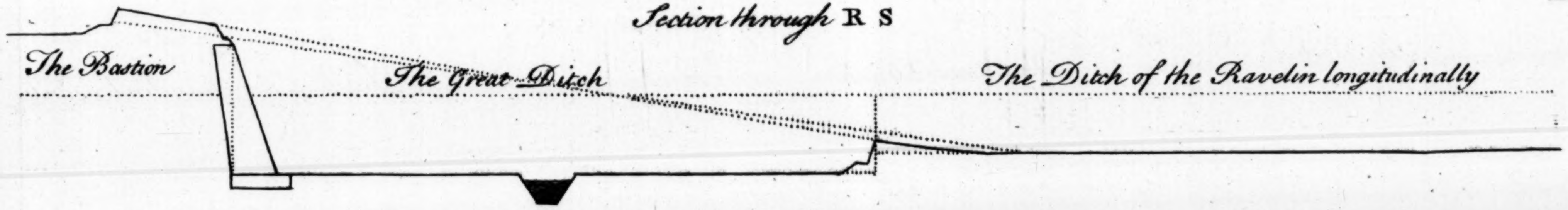
Perpendicular Section through M S. Pl. III.


The Bastion
The Great Ditch before the Shoulder of the Bastion
The Bottom of the Ditch of the Redoute according to its length
The Ravelin
Its Ditch

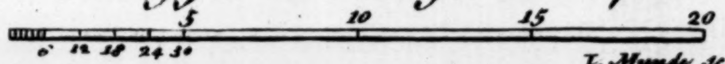
Section through O P



Section through R S



A Scale of feet and Toises for the Profils.



J. Mynde sc.

Pla. III.

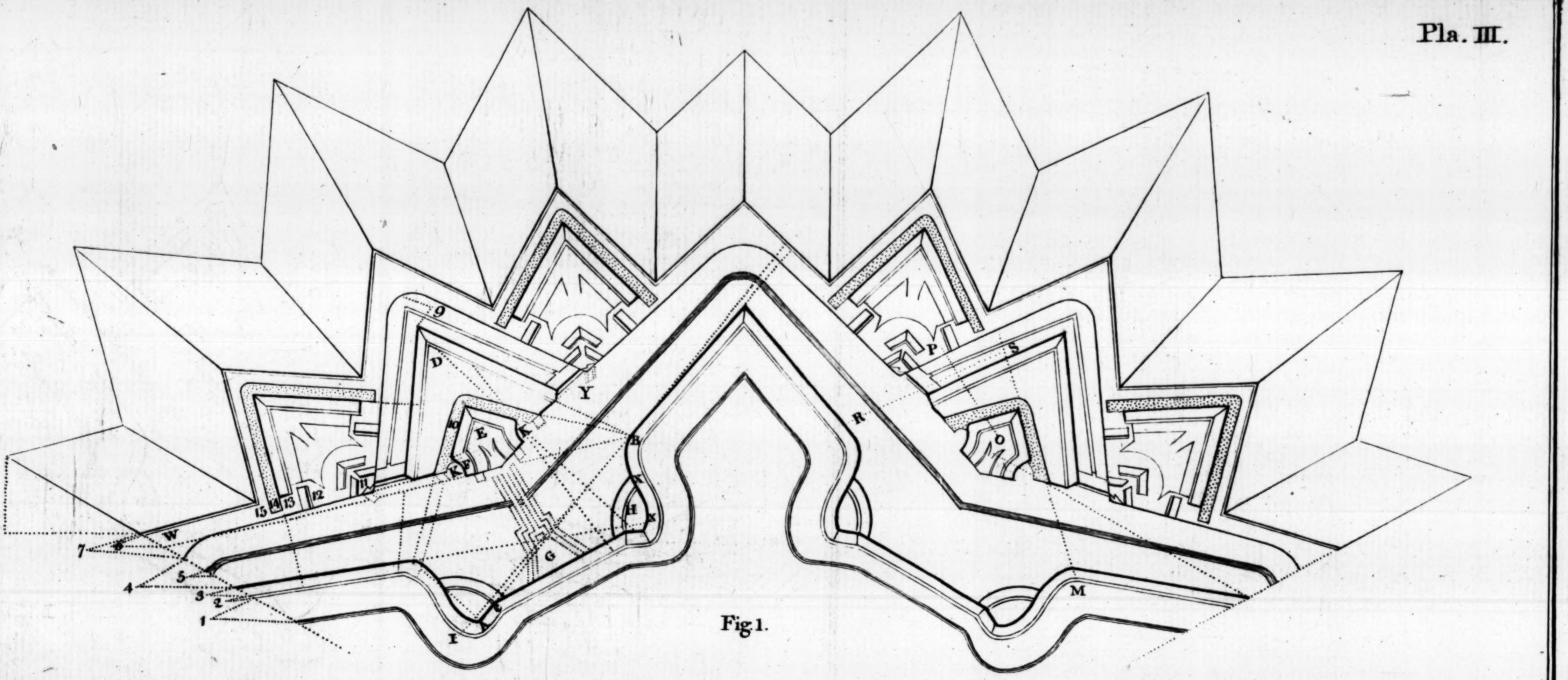
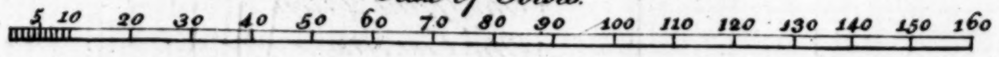


Fig. 1.

The First Method.

Scale of Toises.



1 The Rampart of the Bastion
2 The Footbank
3 The Breastwork
4 The Great Ditch
5 The Cunette
6 The covered way with its Footbank
7 The Saliant Place of Arms
8 The Glacis
H The low convex Flank of the Bastion
G A Retrenched Communication

D The Ravelin
9 Its Ditch & Cunette
E The Redoute of the Ravelin
10 The Ditch of the Redoute
11 The Drum or Retrenchment of the Gorge of the Lunette
12 The Flank of the Lunette
13 Its Breastwork
14 Its Ditch
15 Its Covered way

J. Mynde sc.

Pla. IV.

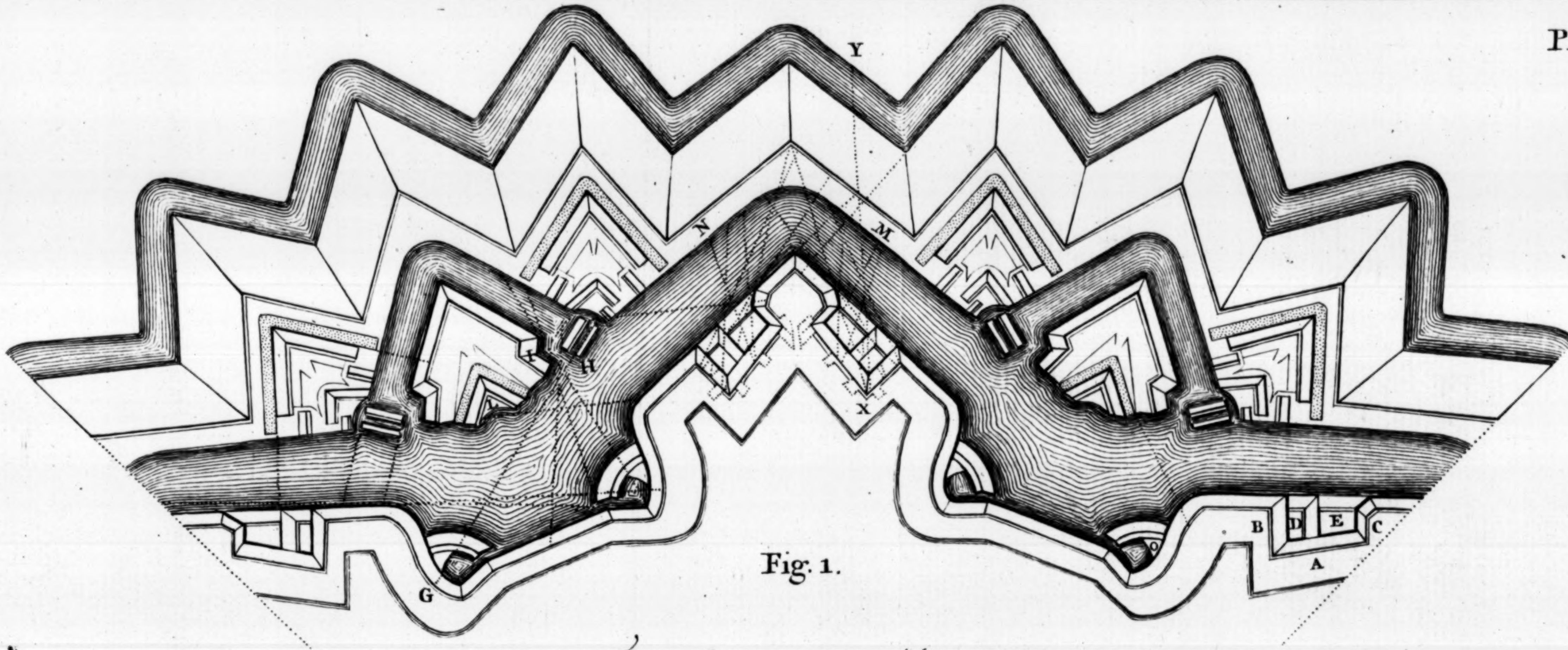


Fig. 1.

The Second Method

A Scale of Toises for the Plan.

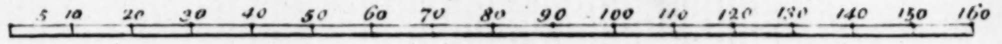
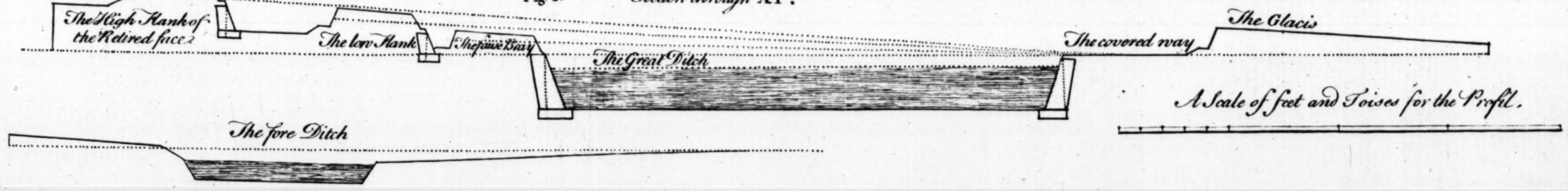


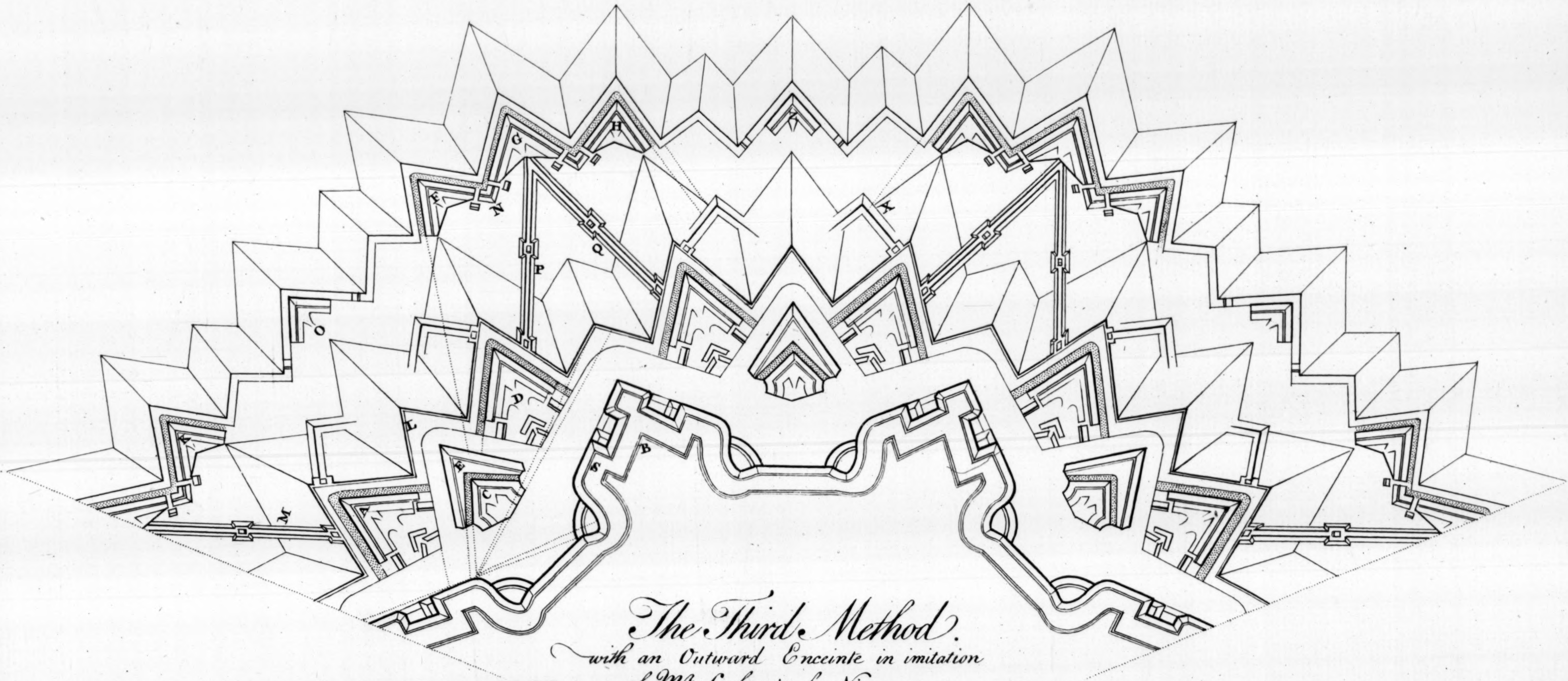
Fig 2. Section through XY.



A Scale of feet and Toises for the Profil.

J. Mynde sc.

Pla. V.



The Third Method.

with an Outward Enceinte in imitation
of Mr. Coehorn's of Nimeguen.

Scale of Toises.

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160

J. Mynde sc.

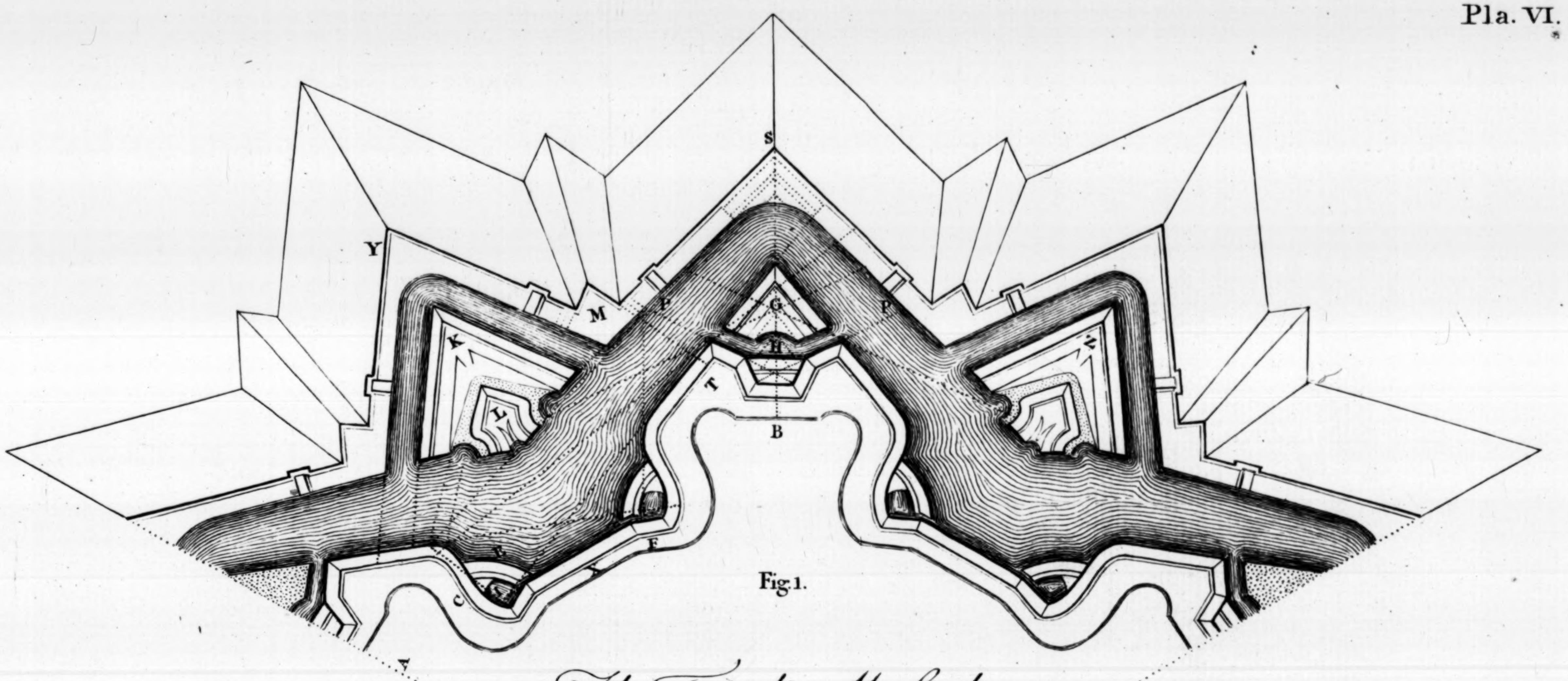
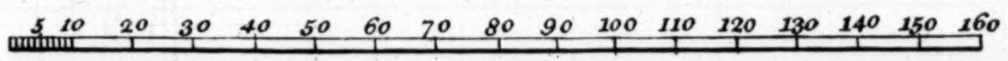


Fig. 1.

The Fourth Method.



Scale of Toises for the Plan.

Section through B.S.

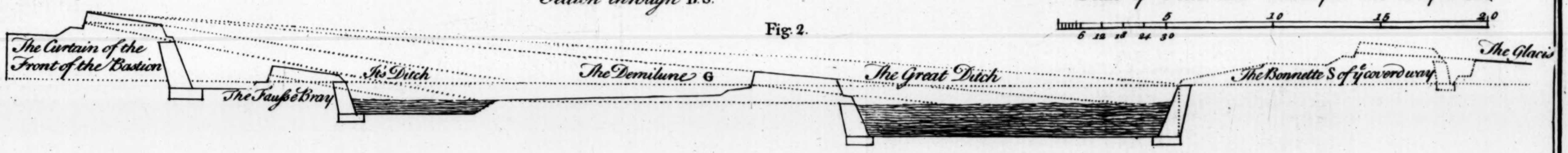
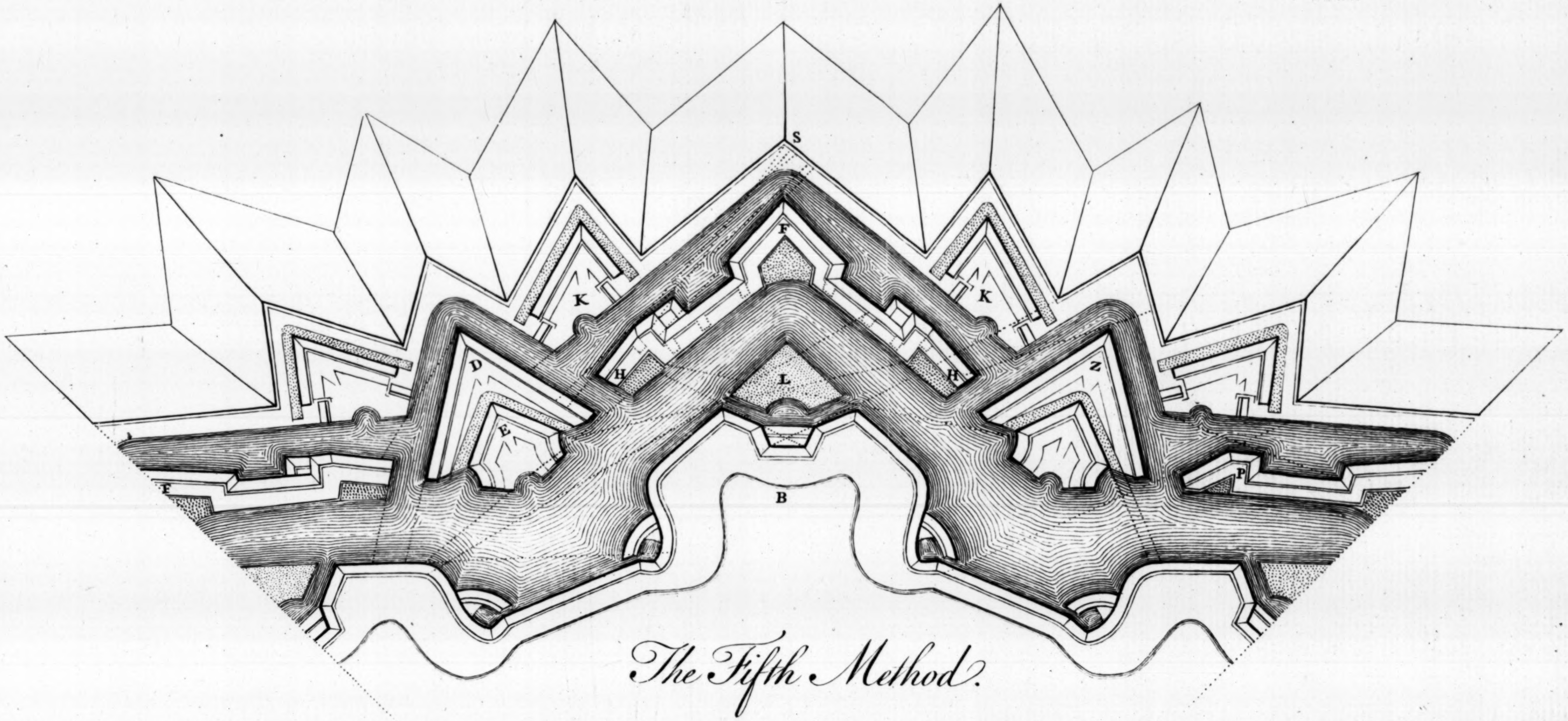

Scale of Feet and Toises for the Profile
5 10 15 20
6 12 18 24 30
The Curtain of the Front of the Bastion
The Fausse Bray
Its Ditch
The Demilune G
The Great Ditch
The Bonnette S of ye coverd way
The Glacis

Fig. 2.

J. Mynde sc.

Pla. VII.



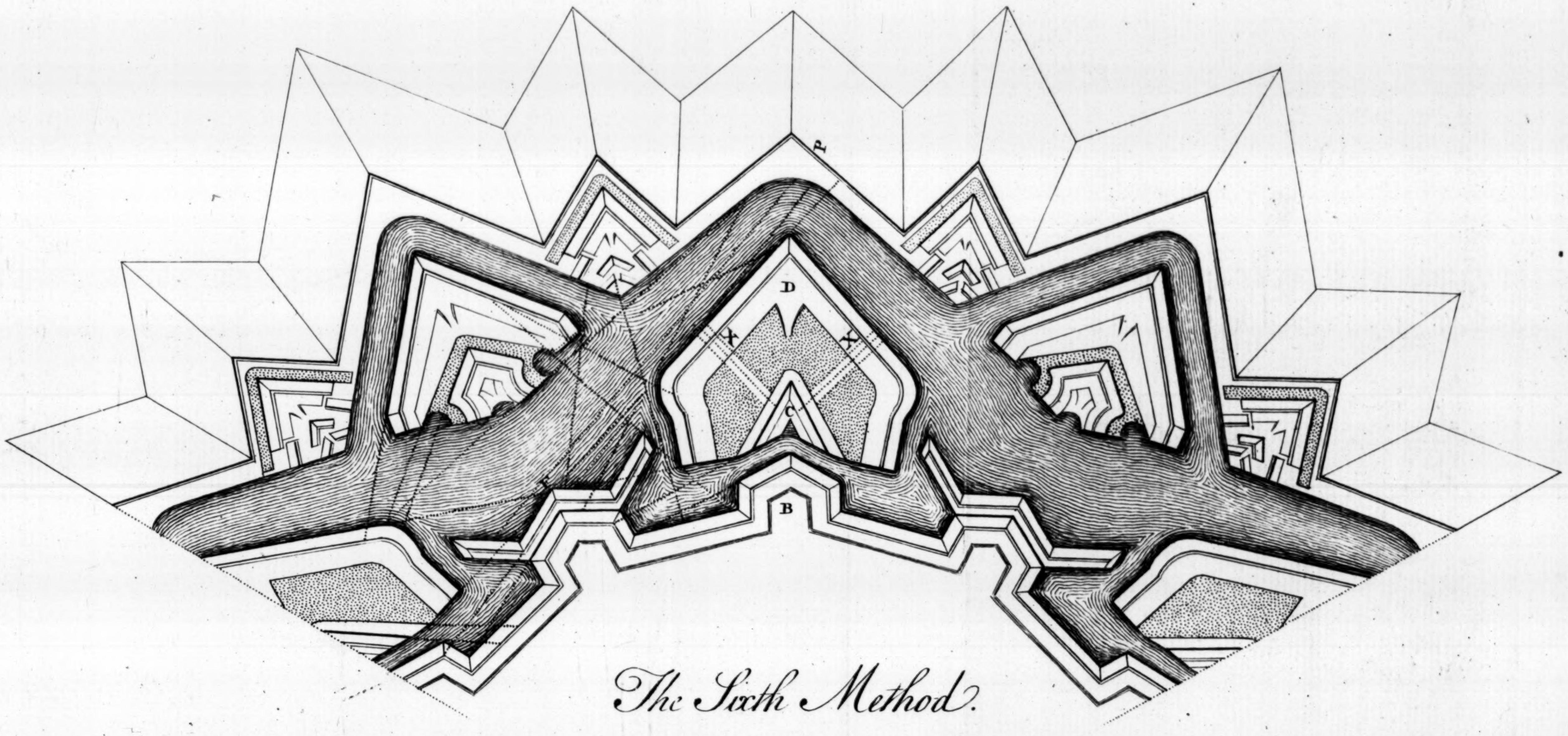
The Fifth Method.

Scale of Toises.

5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160

J. Mynde sc.

Pla. VIII.



The Sixth Method.

Scale of Toises.

5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

J. Mynde sc.

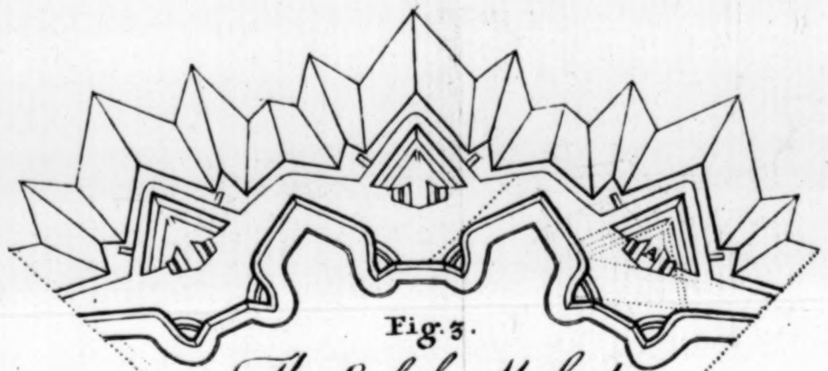
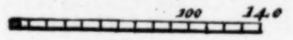


Fig. 3.

The Eighth Method

Scale of Toises for Fig. 3 & 4.



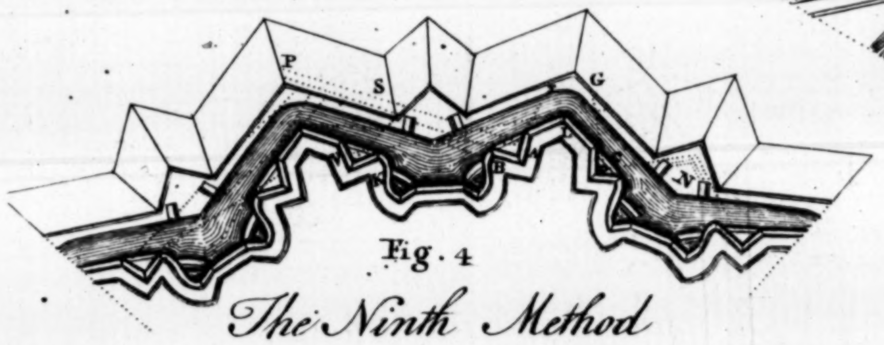


Fig. 4

The Ninth Method

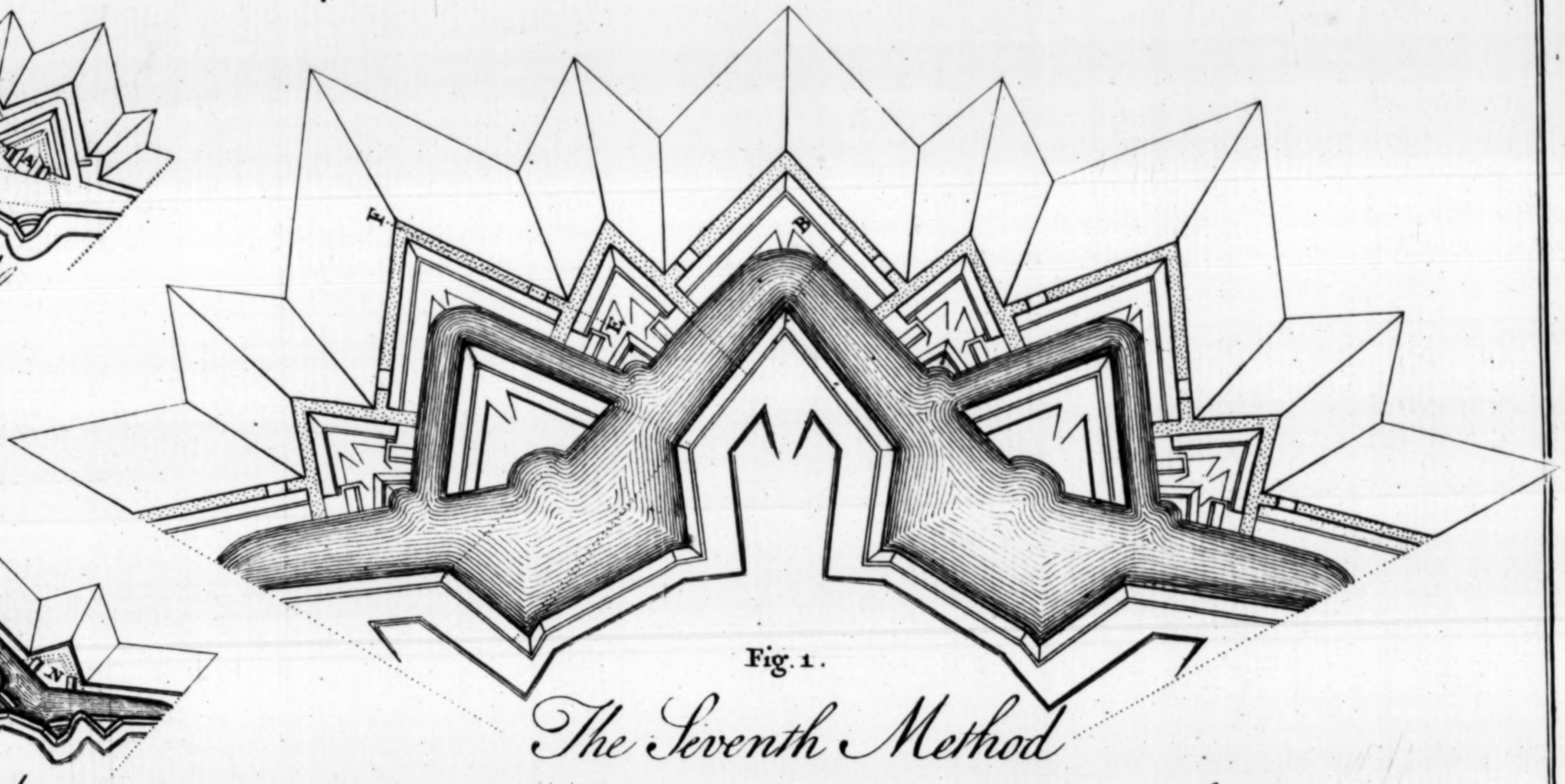
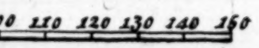


Fig. 1.

The Seventh Method

Scale of Toises for the Plan Fig. 1.



A Perpendicular Section thro' EF Fig. 1.

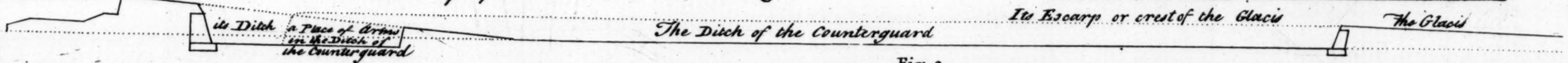
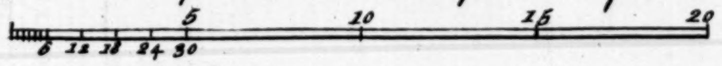

The Lunette
its Ditch
a Place of Arms in the Ditch of the Counterguard
The Ditch of the Counterguard
Its Escarp or crest of the Glacis
The Glacis

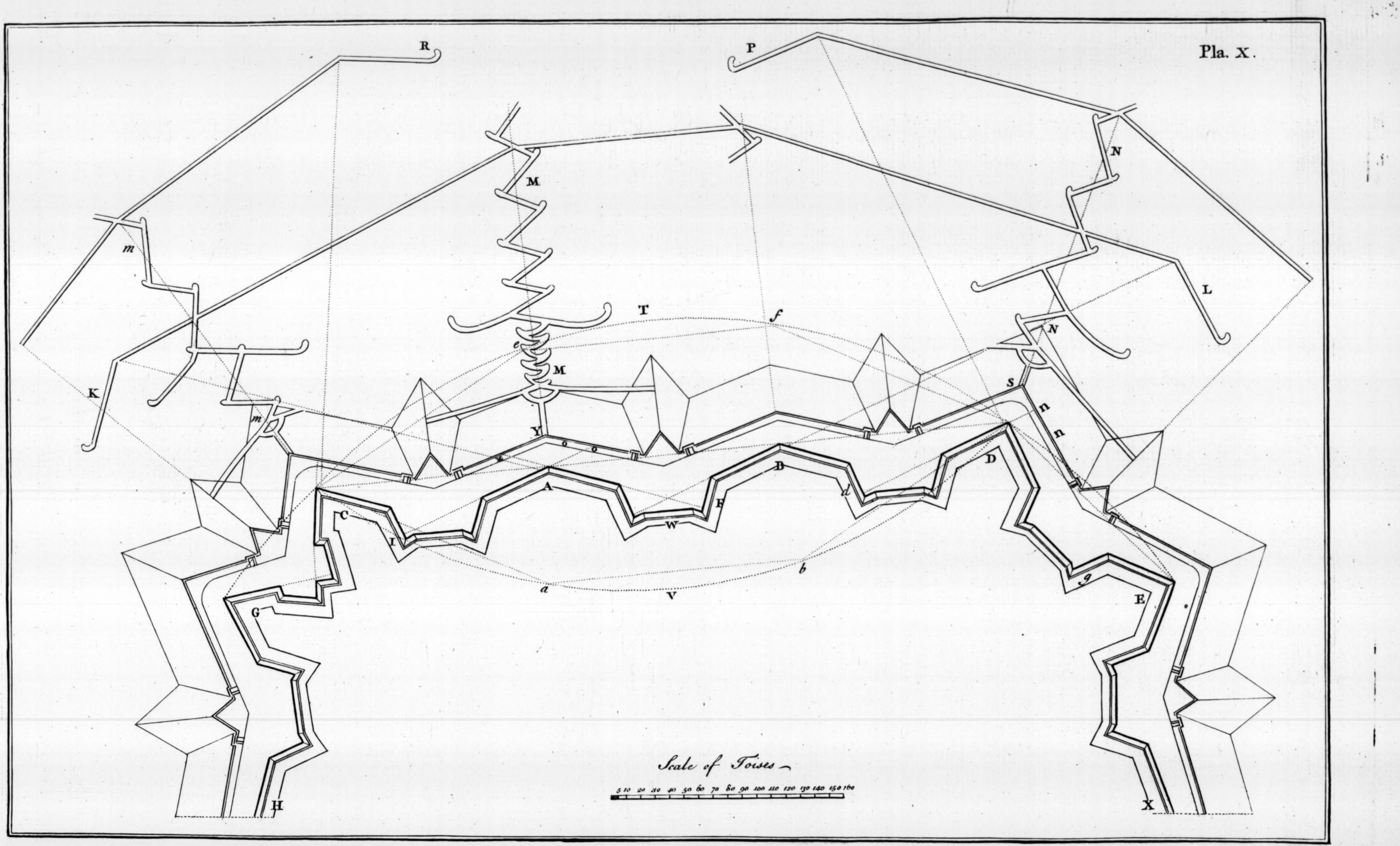
Fig. 2.

Scale of Feet and Toises for the Profil.



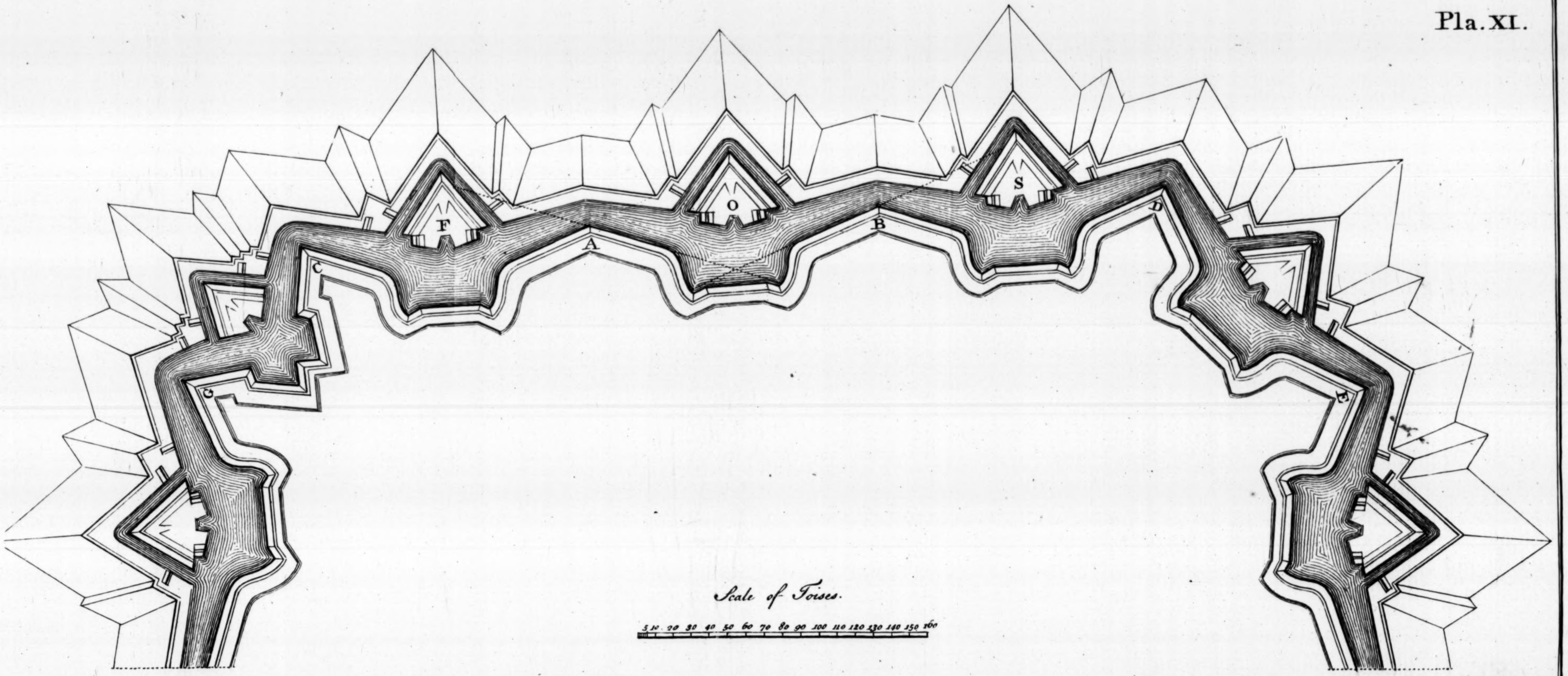
J. Mynde sc.

Pla. X.



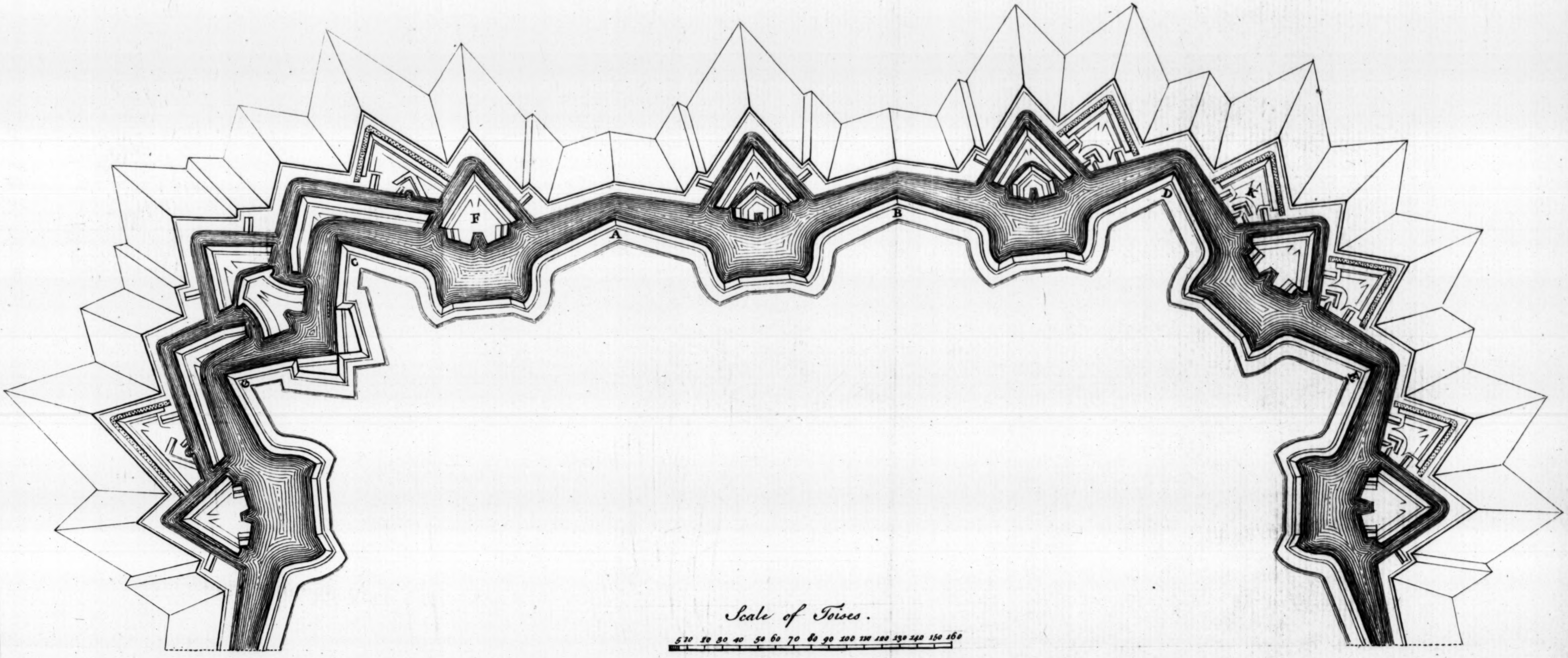
J. Mynde sc.

Pla. XI.

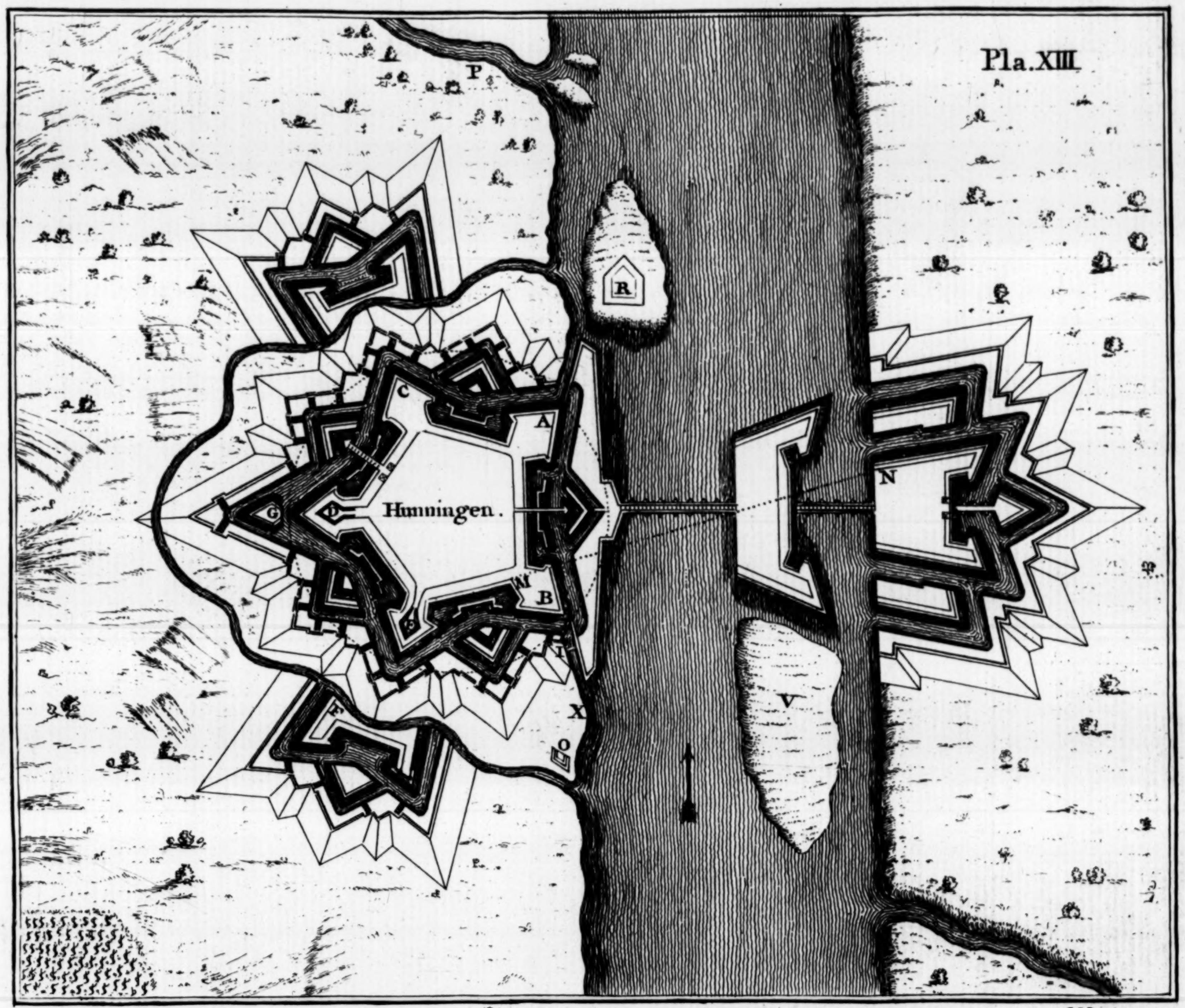


J. Mynde sc.

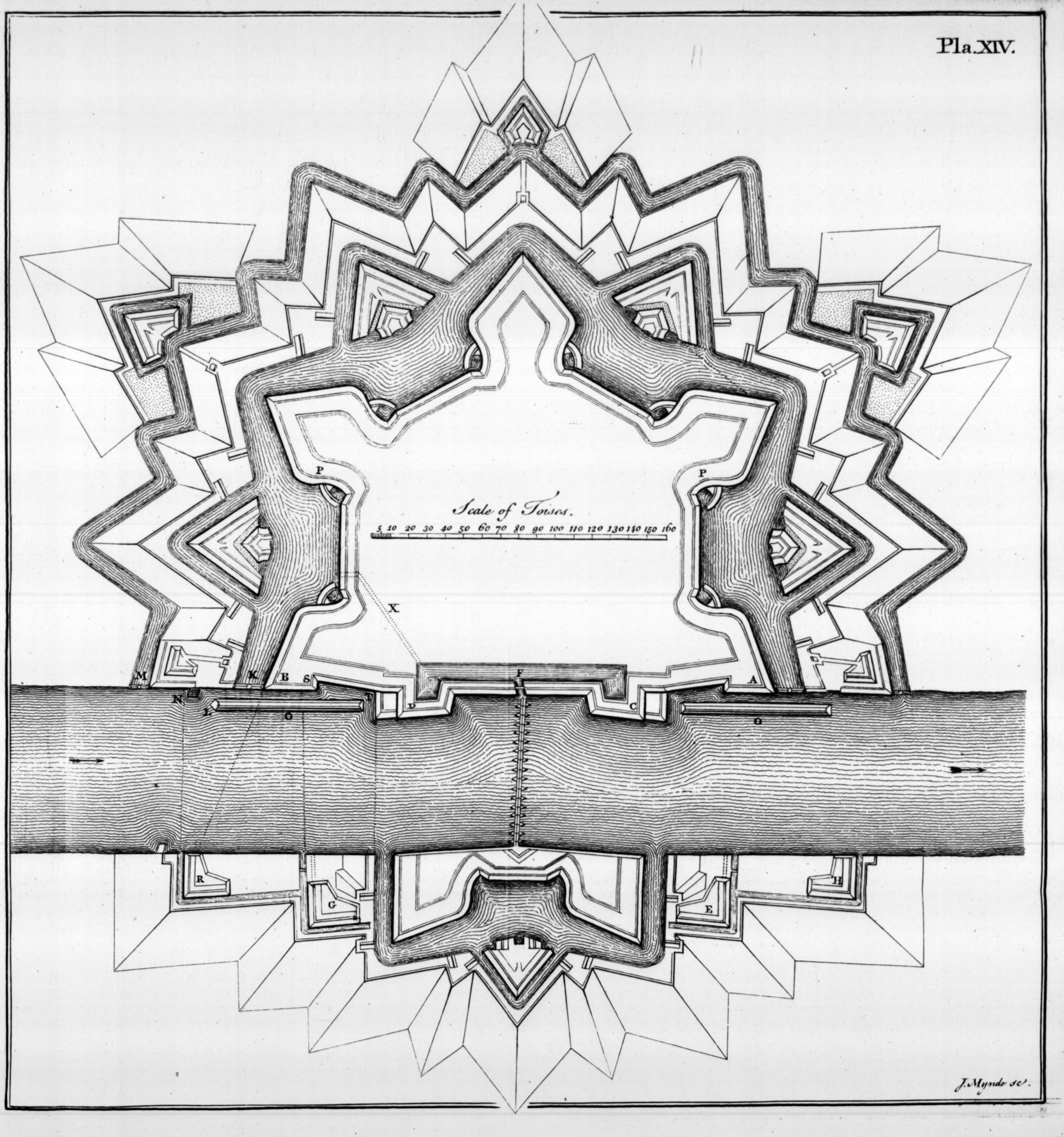
Pla. XII.



J. Mynde sc.

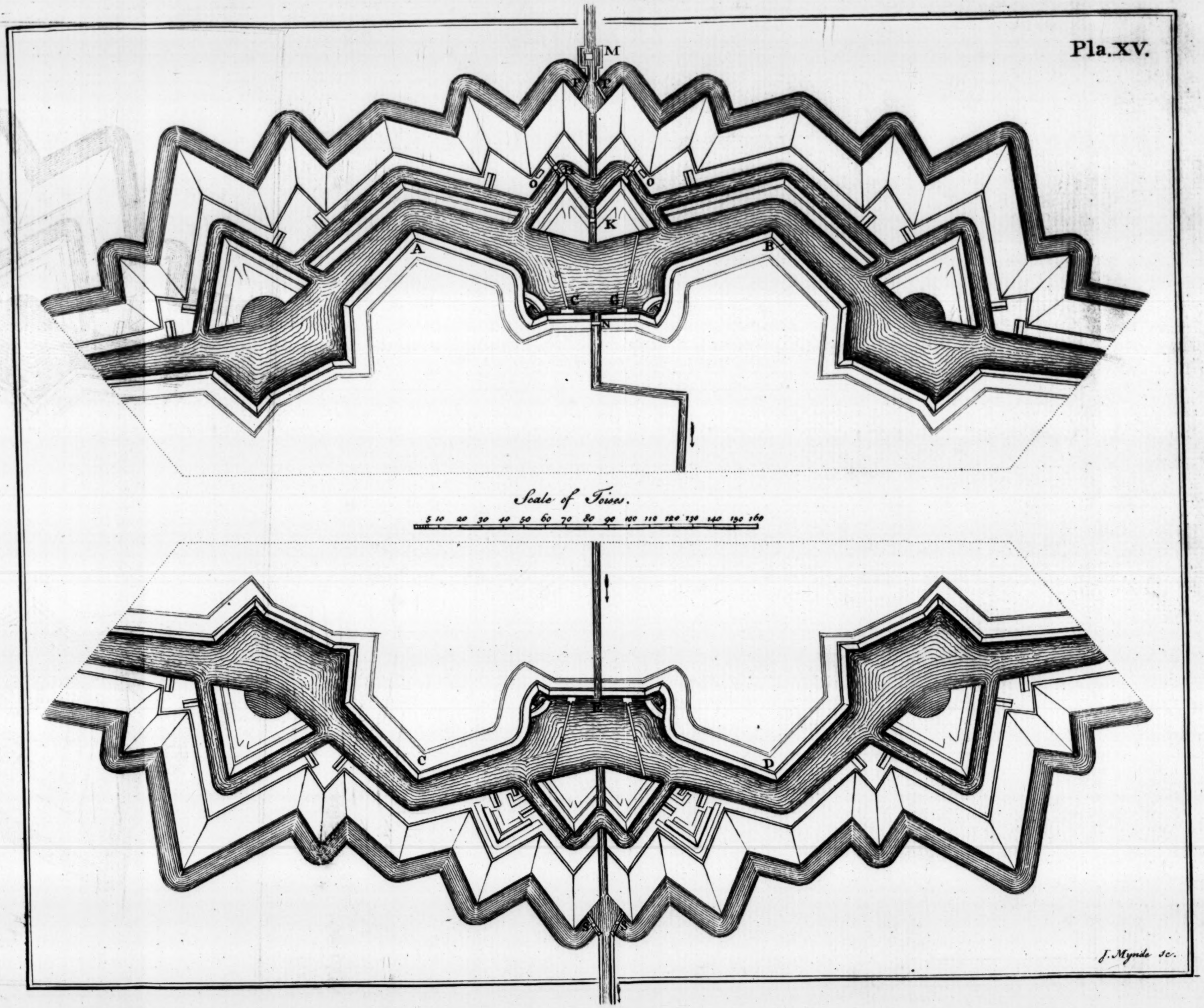


J. Mynde sc.


Scale of Toises.
5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
P
P
X
M
N
L
K
B
S
D
F
C
A
O
O
R
G
E
H

J. Mynde sc.

Pla.XV.



J. Mynde sc.